ELEMENTS OF DAIRYING

By

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PREFACE.

The American Dairy School had its rise in 1891. The instructors had no precedents to fall back upon. A system of laboratory and classroom work had to be evolved. In other words dairying had to be put into pedagogic form. Classroom work was necessarily in the form of lectures, and the lectures have been taking the form of text-books. These books have been written for a twofold purpose; first, for those in the classroom, and second, for the public. This volume has followed this course. For several years the author has used many notes in lectures before his classes and in public addresses. He believes that such a book used as a nucleus around which he can build will enable the students to get a firmer and wider grasp of the subject than by lectures alone, and at the same time he believes that the dairy public is looking for such a treatment of the subject.

During the past fifteen years a great many facts about milk and its products have been learned. These facts have been set in order and constitute the science of dairying.

Other books have been written to cover the field of cheese making, milk testing and dairy bacteriology. No attempt has been made to duplicate those books in this volume, but those things that form the foundation of dairying have been considered. The book has therefore been named "The Elements of Dairying."

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CHAPTER I.

Introductory.

1. Dairy Products Staple Articles.

Milk, butter and cheese have been staple products in the whole history of the human race, but the past century, and especially the last fifty years, has seen a remarkable development in the dairy business.

2. Dairying in Great Britain.

The British Islands produced considerable butter and cheese, but the demand for these products soon exceeded the home supply and nearby European countries as well as America, Australia and New Zealand began to send in supplies. Danish butter is now standard in that market, and Normandy supplies French rolls. By the invention of artificial refrigeration, products from far-off countries are delivered in fresh condition.

3. Rise of the Factory System.

The factory system sprang up in America and a large trade grew up, and with the opening up of trade in China and other Asiatic countries American dairy products are finding a new demand. But their occupancy of that field is to be strongly contested. Russia is also progressing in the dairy business, and Siberian butter and cheese which meet American butter and cheese in the English market, will meet it again in Asia under much more favorable conditions for Russia.

4. Extent of Business in United States.

There are in the United States 17,105,227 milch cows valued at $516,711,914, and an army of about 1,700,000 men are required to care for them, while enough more are engaged in manufacturing and handling dairy products to run the number up over 2,000,000.

There are over 8000 creameries, beside several thousand cheese factories, Wisconsin alone having about 1600.

These cows if put in single file, allowing ten feet of space for each animal, would make a line 32,415 miles long, or would form a procession ten abreast from New York to San Francisco.

They give annually 7,266,392,674 gallons of milk, of which 3,751,107,944 gallons is made into butter, with a skim milk residue of 30,969,147,186 pounds, worth $60,000,000.

5. Some Historical Facts.

In 1810, ten years after settling the Western Reserve in Northeastern Ohio, cheese was carted to Pittsburg for barter. In 1820, Harvey Baldwin, 19 years of age, started with five tons of cheese, made near Aurora, by boat for New Orleans, but sold it out at Wheeling, Cincinnati and Louisville.

About 1835, Charles R. Harmon took six tons of cheese to Fort Dearborn (now Chicago), but went back to Milkwaukee, then of 75 inhabitants, and sold it. About 1852, Mr. Harmon bought cheese five days from the hoop and cured it.

The factory system started in Oneida County, N. Y. In 1851, Jesse Williams and his sons, residing on different farms, brought their milk together to be made into cheese.

In Ohio the first factory was built by Mr. Budlong at Chardon, Geauga County, in 1860. The second one was built in 1861 by Mr. Bartlett at Munson, Geauga County, and the third by John I. Eldridge in 1862 in Aurora Township, Portage County. In 1863, Hurd Bros. built one at Aurora Station, and after that the factory system developed rapidly.

In Wisconsin the factory system started with a factory built in 1864 by Chester Hazen at Ladoga, Fond du Lac County, and one near Watertown, built by Stephen Faville.

The creamery business started later on the gathered cream plan. Wagons driven over long distances gathered up the cream which was churned at the creamery.

In 1879 a DeLaval separator was exhibited at the London Dairy Show. The committee on awards reported it as "a very interesting invention, but thought that it would never become practical in large dairies." It has since revolutionized the butter business and made large creameries possible. The Babcock milk test, invented in 1890, has also brought about many changes as it pointed out unnecessary losses.

The largest creamery in the world is the Continental at Topeka, Kansas. It has 300 skimming stations in Kansas, Colorado and Oklahoma, beside several hundred individual shippers of cream, and in 1902 made 8,000,000 pounds of butter.

On February 15, 1872, seven men, W. D. Hoard, Stephen Faville, W. S. Green, Chester Hazen, H. F. Dousman, A. D. Faville, and H. C. Drake, organized the Wisconsin Dairymen's Association. There were then no through lines of railway to New York, there being four different gauges of track; cheese had to be

transferred from one car to another and large bills for cooperage were sent in, and the cooperage bill became the regular thing. The freight rate from Wisconsin to New York was two cents a pound. Through the efforts of W. D. Hoard, agent of the Wisconsin Dairymen's Association, a rate of one-half cent in refrigerator cars was secured.

This marked the beginning of a rapid development of the factory system in the west, and indeed upon the factory system of the whole country.

6. Dairy Business Changing.

But the dairy business is changing. Many large cities are calling for milk and cream as well as for butter and cheese. Long milk trains run half across the state to supply New York City. Chicago draws its supply from a hundred and fifty miles around, and Cleveland and Pittsburg compete for their supplies, Pittsburg sometimes going within thirty-five miles of Cleveland for milk.

Many cheese and butter factories in these territories cannot compete with the higher prices for milk for consumption, and the character of the business is therefore changing. Trolley lines are also playing a part in the change. The dairy business in the meantime is growing.

7. Effect of Frauds.

This chapter will not be complete without reference to the battle with frauds. Skim cheese is made with the expectation of selling it for full cream; filled cheese made by substituting foreign fat for butter fat almost ruined the business in Wisconsin, and lost the best of the British trade for the United States and it has never been regained. Colored oleo was assumed to be as good as

butter, and was sold for it in such enormous quantities that its output equalled in 1901 the capacity of 1600 creameries. But the producers of dairy products, together with the injured consumers, have asked for fair legislation and have secured the filled-cheese law and the oleo law of 1902.

The United States Navy that carries the flag to distant parts of the world also carries the finest creamery butter put up in three-pound tins. What better thing do American sailors deserve?

CHAPTER II.

The Secretion of Milk.

8. Mammals.

A large class of animals known as mammals secrete a liquid for the nourishment of their young until the young are able to find food on their own account. The milk is secreted in glands of more or less prominence in the different species, and this gland is termed the mammary gland or udder. It is probably a modification of the sweat glands of the skin.

9. Udder Foreshadowed in Lower Animals.

The udder is foreshadowed in lower types of animals, and a gradual development can be traced until the highest development of the gland is found in the domesticated dairy breeds of cows, the extreme development being brought about by the encouragement of nature by man.

In the Ornythorycus, "the glands consist of about 200 club-like tubes opening at two points close together on the surface of the skin. The secretion exudes and the young lick it off from the hair."

"In the Marsupials, the glands are more compacted and small follicles are formed, into which a number of these ducts enter. Each follicle, of which there are ten to twenty in number, empties through a separate duct upon an eminence upon the surface."

This eminence is a rudimentary teat. In the sow, the mare, the ewe, the cow the development is increasingly pronounced.

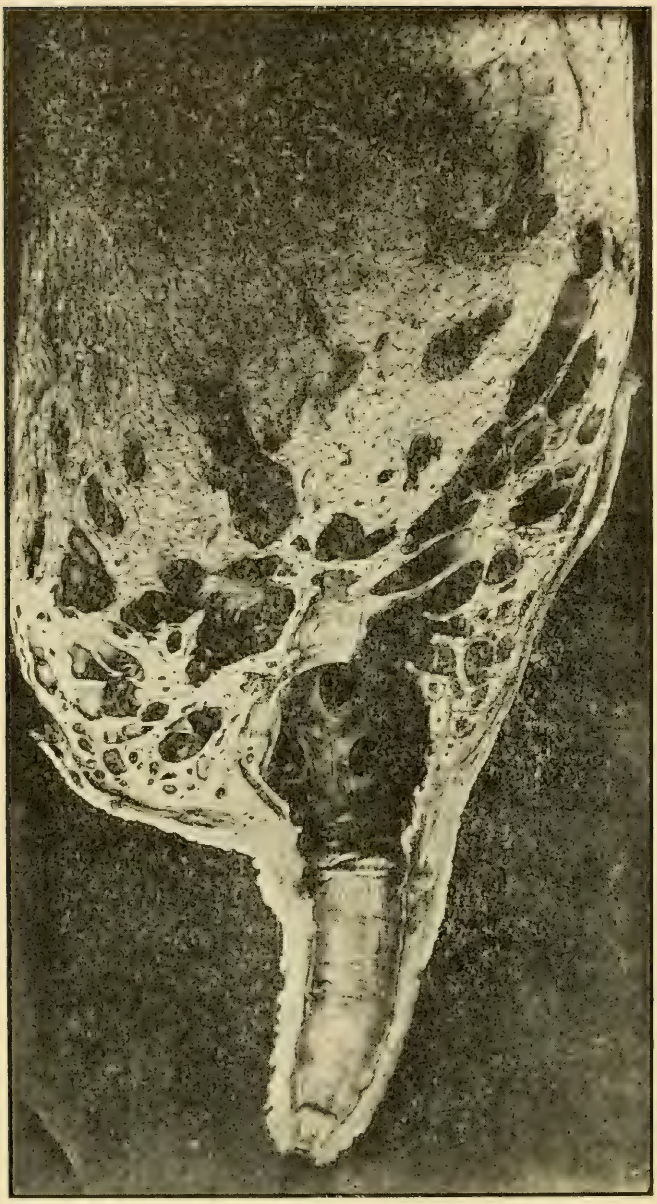
10. High Development of Udder.

A. W. Bitting, in an article in the Twelfth Annual Report of the Indiana Experiment Station, from which we quote freely, says that he has dissected a cow's udder weighing forty-one pounds six ounces. A Holstein Friesian cow in Wisconsin is reported to have measured nearly six feet around the udder, or within two inches of her heart girth. Cows have been reported to have secreted over a hundred pounds of milk in a day,—their own weight in less than two weeks, and over ten tons in a year.

11. Structure of Cow's Udder.

The udder of the cow is one large gland with four distinct quarters. It is suspended from the abdominal walls in a fibrous capsule, and is held together by fibrous tissue. A longitudinal fibrous partition divides the udder along the median line very distinctly into two halves. Dr. Bitting has shown by injecting colored liquids through the teats, that the halves are again very distinctly divided into quarters, and that only that milk produced in any quarter can be drawn from the corresponding teat.

A longitudinal section of a quarter and teat shows that the opening of the teat is guarded with a sphincter muscle. A cavity through the length of the teat is lined by folds of the tissue when empty, and just above the teat is another cavity known as the milk cistern. This is not large, holding but a few ounces, and ducts open from this into the tissue of the gland. Following these ducts they will be found to divide into smaller branches which eventually end in little groups of cavities, the alveoli or ultimate follicles. These alveoli are in groups which may be likened to a small bunch of grapes. They



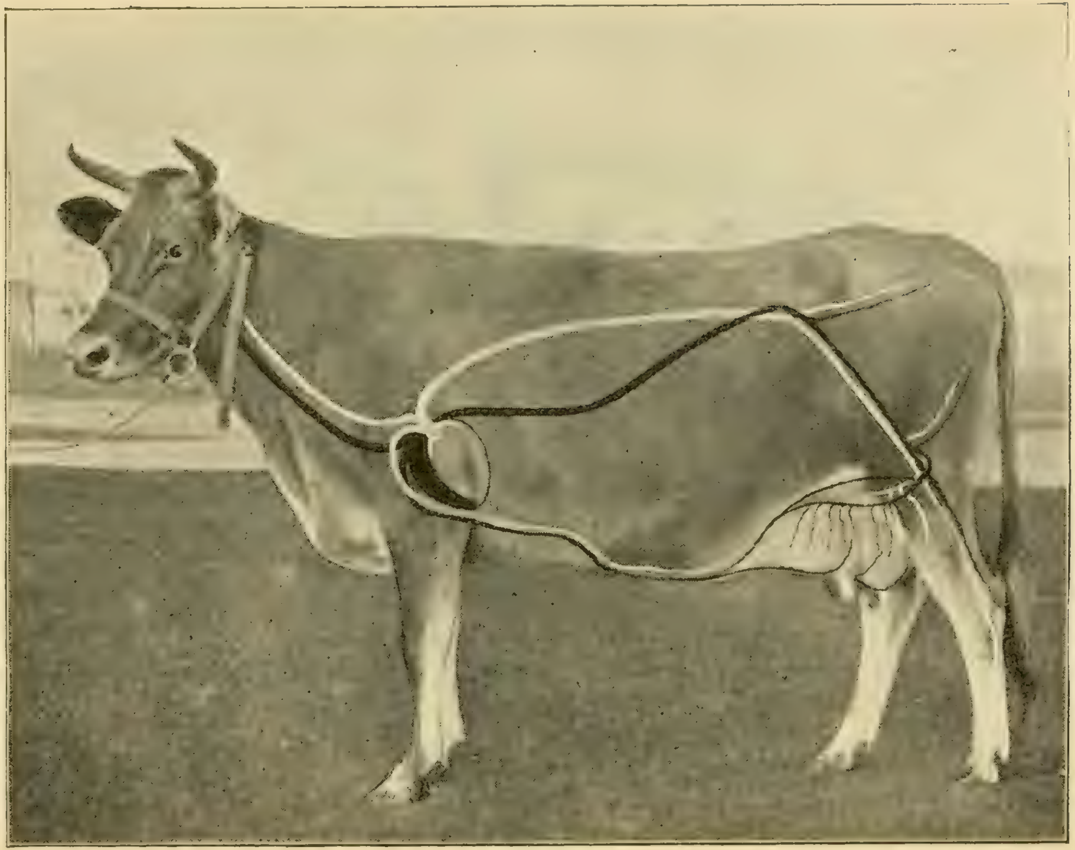
Longitudinal section of a quarter of an udder.
Cornell Experiment Station.

are lined by epithelial cells which derive their nourishment from little blood vessels surrounding them. They vary in size from one two hundred and fiftieth to one one hundredth of an inch in length and from one thirteen hundredth to one eight hundredth of a inch in diameter.

The blood leaves the heart through the posterior artery which divides in the region of the hips, where it again divides into two arteries, the common illiacs, and again into two more arteries from which, after it has divided into many small capillary arteries, the cell tissue in the alveoli is fed.

12. Milk Veins.

The cells use such portion of the blood as they need, and capillary veins begin to gather the venous blood into ever enlarging veins, until it is collected in a system of large veins just under the skin and surrounding the upper part of the udder much like a rope tied around it. From this surrounding vein or rather group of veins, for according to Bitting, there are 14 to 17 of them, large veins run from the fore part and posterior part of the udder back to the heart. These are the so-called milk veins. They do not contain milk, but are an indication of the milk-making capacity of the udder, as they indicate the quantity of blood used in the gland. If there happens to be pressure on the anterior veins the blood may return to the heart by way of the posterior veins, and it is possible to have a large milker with small visible milk veins, but this is not likely, and it probably never occurs that an animal having large milk veins is a poor milker. The veins run forward, are often very tortuous and may branch several times and enter the chest wall through openings, which are termed milk wells, and are sometimes large enough to insert the end of the finger.



Schematic figure of a cow showing flow of blood between the heart and udder. The light lines are arteries and the dark lines veins. From A. W. Bitting, Report XII, Indiana Experiment Station.

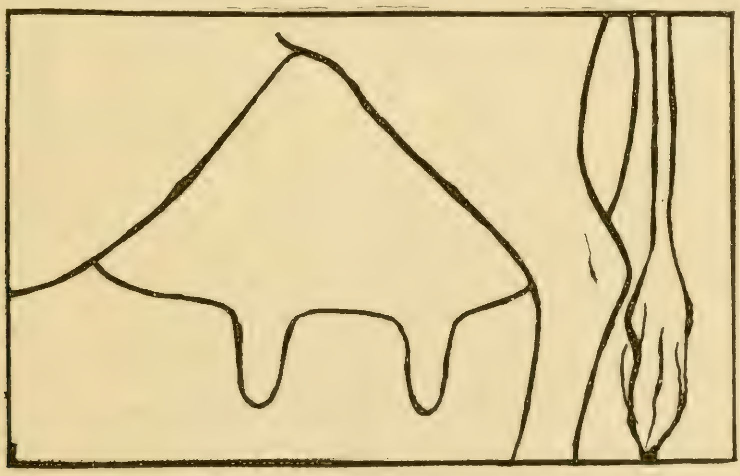
13. Quality of Udder.

Many udders consist largely of fibrous tissue and are termed "fleshy." Such an udder does not contract upon milking as will an udder composed more largely of glandular tissue. Some udders can be so milked out that they very largely disappear.

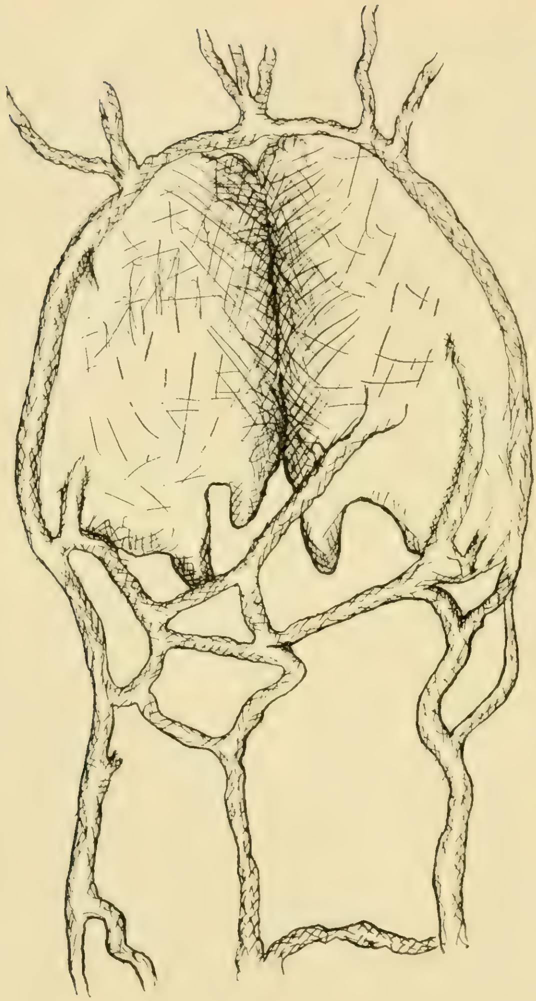
An udder of a young animal may be deceiving as it is held firmly to the abdominal walls. In heifer calves on the sides, just above and in front of the flanks, may be found cords which later help to support the udder, and the size and strength of these cords is said to be an indication of the udder capacity of the animal in the future. In old cows which have been heavy milkers, the udder, on account of the heavy weight of milk it has carried, may be drawn partially away from the abdominal walls and be termed a pendant udder.

14. Form of Udder.

There is a natural tendency in cows for the rear quarters of the udder to develop much more than the

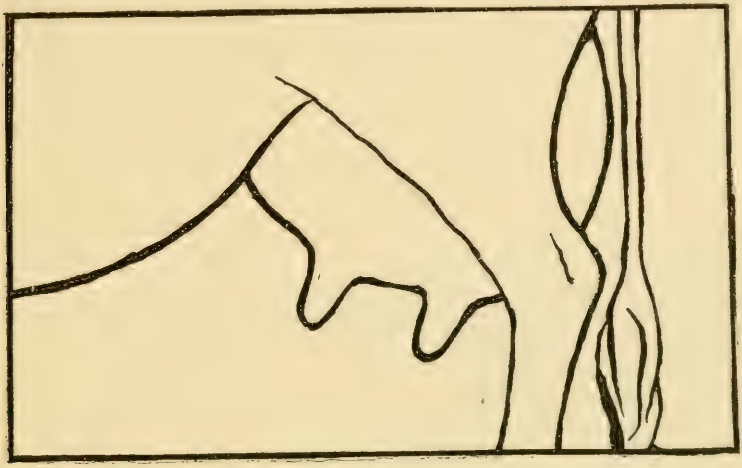


Outline of square, well developed, udder.



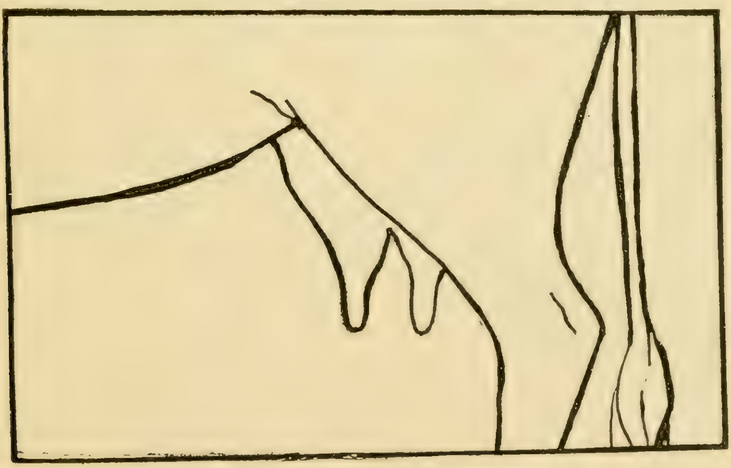
Pen drawing of a dissected udder and milk veins as seen from above. Drawn from original photograph, by Dr. A. W. Bitting. Shown in Twelfth Report of the Indiana Experiment Station.

fore quarters. The wise dairyman tries to develop the fore quarters, encouraging them to develop well forward, making what is termed a square udder. The teats should



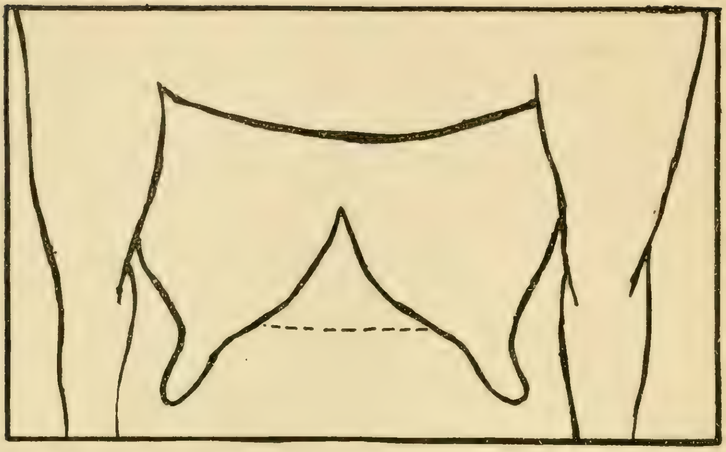
Outline of udder lacking in fore-quarter development.

not be too prominent, for if the udder is cut up between the teats it is at the expense of glandular tissue. A

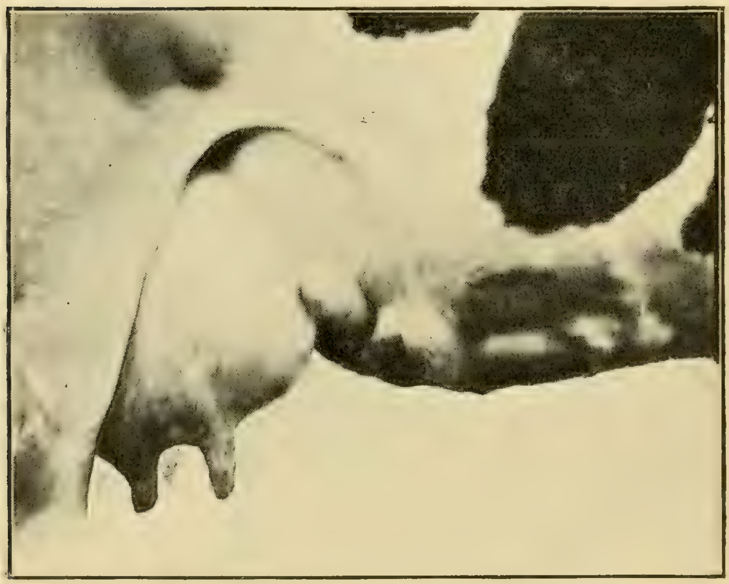


Outline of a funnel-shaped udder

funnel-shaped udder is one in which the teats are very prominent and the quarters of the udder small, so that



Outline showing cut-up udder. The ideal udder would be filled out along the dotted line.

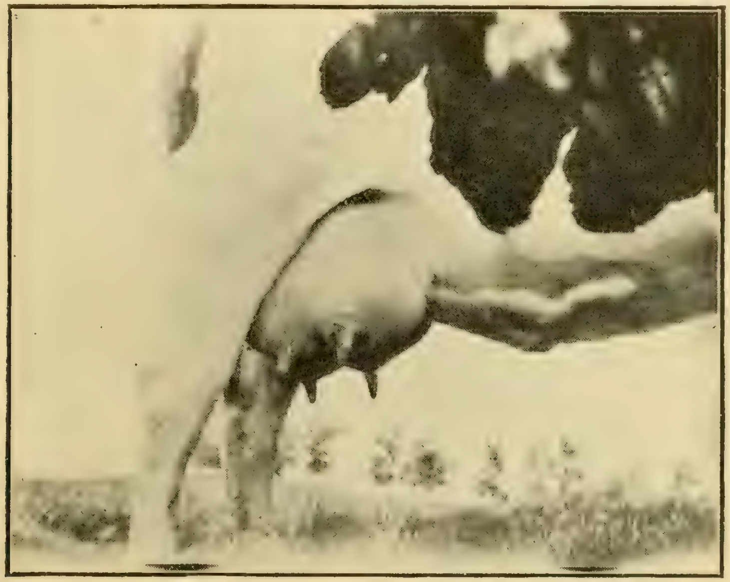


Udder and milk veins of Johanna De Kol 2d, Holstein Friesian cow, owned by Gillett & Son, Rosendale, Wis. She gave 17,000 pounds of milk containing 644 pounds of butter fat in her four year old form.

the udder is shaped like a funnel. The teats should be set well apart and be large enough to grasp well with the hand.

15. Theory of Milk Secretion.

The theory of the secretion of milk held by most authorities is that the cells in the alveoli are gradually built up between milkings. At the time of milking the agitation causes these cells to break down into milk.

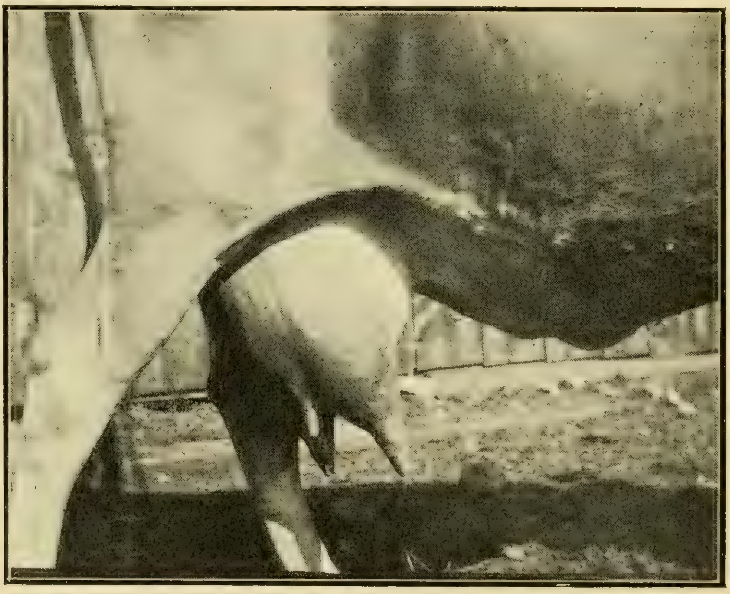


Udder cut-up between the halves.

The reason put forward for this theory is that when an udder is cut open very little milk is found. If one has observed a nursing calf, lamb or kitten, considerable agitation of the udder was apparent.

It has been shown by Professor Woll that it is very necessary to agitate the udder in order to get all of the milk, that some milkers milk their cows apparently dry, but immediate subsequent agitation of the udder will

bring down considerable milk. He estimates that if the million cows in Wisconsin average as the cows with which he has experimented, with butter fat at 20 cents per pound, the value of the milk thus secured would be worth six millions of dollars. On the same basis with the 800,000 milch cows in Ohio, the annual income could be increased by $4,500,000. The method of manipulation employed by Professor Woll was first suggested by a Swede by the name of Helgelund.



Abnormal-shaped udder.

16. Milk a Secretion.

The milk is a distinct substance manufactured in the cells of the udder. It is not strained from the blood. Milk fat, as will be shown later, is different from beef fat, and milk sugar is found nowhere else in nature—it is a sugar peculiar to milk. The proteids of milk are also different from the proteids of the body.

As soon as broken up into milk, the secretion finds its way down the milk ducts into the milk cistern and teat.

Professor John H. Shepperd, while at the University of Wisconsin, conducted some experiments in the order of milking the teats, and in competing with a calf for the quantity of milk obtained. The calf was weighed before and after milking, and manipulated one side of the udder while the regular milker managed the other side. The next milking they would change sides, etc., to get complete checks. It is interesting to note that the calf was not superior to the man in the contest.

Some milkers are, however, superior to others. By looking over the milking records at the University of Wisconsin, it was possible to pick out the cows milked by a certain milker, for he could (or rather did) invariably get more and richer milk from the same cows than when the cows were milked by other men.

It was a noticeable fact that this herd of cows always gave less milk on Sunday than other days of the week, probably because the milkers were in more of a hurry that day and did not do their work as thoroughly.

17. Selection of a Cow.

It has been observed that the milk is made from the blood. In selecting a cow it should be remembered that blood is made from food and the cow should have a large chemical laboratory in her make-up for the digestion of food. There should be a good heart girth also, for the heart has to pump immense quantities of blood and the lungs are called upon to purify this blood. The nervous system also has a part to play for a large nerve branches off from the last dorsal vertebra and goes into the udder to control operations there. A prominent

backbone and long tail indicate a good nervous development. The animal should not be tied together with thick beefy flanks, but should have plenty of room for the location of an udder and should have a distinct tendency not to put the food on her frame in the form of flesh, but to turn it into milk.

CHAPTER III.

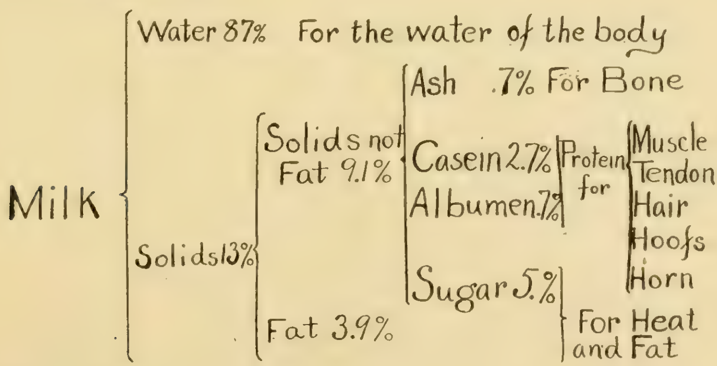
Water and Solids of Milk.

18. Composition of Milk.

Milk contains all the food elements necessary for the development of the young animal. Not only do these food elements vary in their percentages in the milk of any one species, but the variations are still greater among different species. The relative amount of development of the animal at birth produces different requirements as to food.

At first thought it may seem easy to give a statement concerning the composition of average cow's milk, and this we will attempt to do, but as we study the subject it will be found that many factors come into play so that it is very difficult to determine just what is average milk.

The following diagram will express to the eye in a general way the composition of what we may be pleased to call average milk.



But milk grows richer in solids as the period of lactation advances. Certain breeds of cattle give richer

milk than others, and whole herds of cattle may give milk quite different in composition from other whole herds of the same breed.

With these facts in mind we will study some of the variations.

19. Average Milk.

It has been thought that the reports of tests and analyses of milk from a great many cheese and butter factories would give a fair average. Dr. Babcock secured reports from dairy students in Wisconsin distributed over a large territory upon which he based some conclusions, and Dr. VanSlyke, in New York, made careful and extensive analyses of milk in cheese factories and arrived at about the same conclusions as Dr. Babcock. There are, however, localities where the stock has been crossed largely with Jersey blood where the results are too low, and again reports come from certain sections of Europe that are lower than the results of Drs. Babcock and VanSlyke.

Dr. VanSlyke gives the following averages of cheese factory milk from the results of three years' work.

It is customary for the cows to come fresh in the spring and the milk to be carried to the cheese factory for six or seven months. It will be seen that the relation between water and solids varies from month to month.

Table showing relation between water and solids in New York cheese factory milk:

Month.	Per Cent. Water.	Per Cent. Solids.
May	87.44	12.56
June	87.31	12.69
July	87.52	12.48
August	87.37	12.63
September	87.00	13.00
October	86.55	13.45

Dr. VanSlyke calls attention to the fact that in July the lower solids are due to a drouth.

20. Effect of Length of Lactation Period.

The preceding table is, it will be seen, cheese factory milk. Dr. VanSlyke has taken a herd of fifty cows calving in different months of the year and arranged averages of the months in lactation with results quite different from the cheese factory milk as follows:

Averages according to months in lactation of fifty cows:

Month in Lactation.	Per Cent. Water.	Per Cent. Solids.
1	86.00	14.00
2	86.50	13.50
3	86.53	13.47
4	86.36	13.64
5	86.25	13.75
6	86.00	14.00
7	85.82	14.18
8	85.67	14.33
9	85.54	14.46
10	85.17	14.83

A person observing this second table, if he did not have the cheese factory averages before him, might conclude that the average given in our diagram is entirely out of the way.

21. Effect of Breed.

At the Geneva Experiment Station a breed test was conducted for several years. There were three to seven cows in each herd and the test ran from six to seven years. Other animals in the different breeds would probably have given somewhat different results from those obtained, but comparing these results with many other analyses we conclude that the figures are typical of the breeds.

They are as follows:

EFFECTS OF BREED ON COMPOSITION OF MILK.

Breed.	Per Cent. Water.	Per Cent. Solids.
Holstein	88.20	11.80
Ayrshire	87.25	12.75
Shorthorn	85.70	14.30
Devon	85.50	14.50
Guernsey	85.10	14.90
Jersey	84.60	15.40

The lowest testing and highest testing animals in the six breeds would make the difference still more marked.

22. Legal Standards.

It was formerly very difficult to convict a man of adulterating milk for the reason that if he was really seen to water the milk it was still more difficult for the witness to follow it until delivered and be able to swear that the milk delivered was really the milk seen to be watered. Most states now have laws establishing legal standards for milk which state that a chemist's analysis shall stand for evidence in court.

Some of these laws establish a standard for total solids. The Ohio law, for instance, requires twelve per cent. of total solids excepting in May and June, when it may be as low as eleven and a half per cent. This latter clause probably grew out of the fact that cheese factory milk tested low in these months. If the table showing effect of period of lactation be examined again, it will be seen that the milk grows poorer until about the third month and from that time on grows richer again, following the abundance of milk flow, the solids being least at the time of greatest flow. The plan on which the cheese factories operated was to have the cows come fresh in March and April and the flush of milk would come in May and June. But factories are now operated the year

round and milk in factories is coming to be paid for by test, while the large amount of milk sold for consumption is sold the year round. The eleven and a half per cent. clause is evidently unjust.

It has been decided many times in court that milk testing below a legal standard, though given that way by the cow, can be considered adulterated. In the eyes of the law, it does not matter whether the excessive water was put into the milk by a man or not.

CHAPTER IV.

MILK FAT.

23. Chemical Composition.

Milk fat is a mixture of a number of compounds and is made up of carbon 75%, hydrogen 13%, and oxygen 12%. The substances in the mixture are palmatin, olein, myristin, butyrin, laurin, caproin, stearin, dioxystearin, caprylin, and caprin.

Palmatin melts at 144° F. and myristin at 129°, while olein and butryin are liquid at ordinary temperatures. Together they form a mixture in the form of milk fat that melts at 87° to 90° F. The proportions vary somewhat so that the melting point of the milk fat varies, as for instance, the fat in the milk of stripper cows has a higher melting point than normal. Oil meal and gluten meal fed to cows will lower the melting point, while cotton seed meal will raise it.

Butter fat is the glycerides of the fatty acids corresponding to the above named fats. That is, glycerine 12.5% unites with 87.5% of the fatty acids to make the fats named.

24. Saponification.

If the fat is boiled with an alkali the latter takes the place of the glycerine and makes a soap. If now the soap be boiled with an acid, the acid added will unite with the alkali of the soap and set the fatty acids free. These fatty acids appear to the eye to be fat. The Short milk test, which was invented at the Wisconsin Experiment

Station by Chemist F. G. Short, now associate editor of Hoard's Dairyman, depended upon these reactions. A sample, 20 c.c. of milk, was measured into the test bottle; then 10 c.c. of a potash solution was added and the mixture boiled for two or three hours, when the milk fat was turned to soap. Then 10 c.c. of a mixture of acetic and sulphuric acids was added and boiled for two hours longer. The fatty acids as they were liberated from the soap would collect in the neck of the bottle.

Later when Dr. Babcock invented his method of testing milk, he used the Short test bottle and made his pipette 17.6 c.c. to correspond to the scale on the Short test bottle which included a volume of two cubic centimeters.

25. Difference Between Butter Fat and Oleo.

The fatty acids of butter fat are a mixure, the same as the fat is a mixture of a number of fats. Some of these fatty acids are volatile, and here is a distinguishing difference between butter fat and oleo. The Reichert-Wollny test is based upon this fact.

Five grams of the fat in question is weighed into a flask. A potash solution is added and the mixture boiled until the fat is turned to soap. Then sulphuric acid is added and the flask attached to a still. It is then gently distilled so that 110 c.c. of distillate goes over in thirty minutes. The volatile fatty acids are driven over in the distillate, and when this is titrated with a standard alkali solution, the amount of volatile acid driven over can be determined. If the fat in question was butter fat it would require twenty to thirty-five c.c. of the decinormal alkali used to neutralize the acid in the distillate, but if oleo, one or two c.c. would be sufficient. If it

was a mixture of oleo and butter fat, an amount between that of oleo and butter fat would be required.

The amount of volatile fatty acids in butter fat vary somewhat. Fall pastures and stripper cows have the effect of decreasing them in the milk.

26. Tests for Oleo.

It is a rather difficult task to distinguish between oleo and butter fat on the market. Oleo will not get rancid like butter fat because of the lack of these lighter fats. If oleo be melted in a spoon over a gas jet it will simply melt down quietly, while butter will froth.

27. Color of Milk.

The color of milk is called lactochrome, meaning simply milk color. We do not know just what it is. It is more evident in the milk of fresh cows on succulent feed or good pasture. It is also more noticeable in the milk of Guernsey and Jersey cows.

It is in the butter fat as is quite evident by watching a centrifugal cream separator, when it will be seen that the cream has a yellowish color, while the skim milk is quite white. In making butter and cheese, artificial coloring matter is added to make up the deficiency of color at certain times of the year. The color thus added is either annato—made from the coating of annato seed or an analine color. The cheese color is made by boiling the seed in lye and colors the casein, but butter color has the color dissolved in oil and will therefore be incorporated with the butter fat, but will not mix with the butter milk.

28. Fat Globules.

Fat will not dissolve in the water of the milk, but is in emulsion. It is broken up into minute globules that

vary in size from 1-1500 to 1-40,000 of an inch in diameter; that is, it would take 40,000 of the smallest globules placed side by side to make a row an inch long.

29. Numbers in a Drop.

There are 150,000,000 of them in a single drop of milk and it would require 30,000,000,000 to weigh a single grain. It was estimated that the cows in the herd at Cornell University manufactured on the average 38,210,000 of them per second.

30. How Counted.

The reader may wonder how it is possible to count such a large number in so small an amount of milk; for counting two per second, and working steadily 12 hours per day, it would take 180 days; or how they can be picked out of the drop of milk and laid aside one by one so that they will not be counted a second time? It is done as follows in a very few minutes: A small glass tube, such as can be procured at the drug store, is heated in a gas lamp and two men run in opposie directions with the ends. This draws the tube out into a fine hair-like tube. The milk in question is then diluted fifty times with water, so that there will be only one globule where formerly there were fifty. The diluted milk is drawn into these little tubes and the ends plugged with vaseline. The tubes are put under a microscope and there in the tubes are seen the little fat globules, ten or a dozen or twenty. By means of a micrometer in the microscope the length and diameter of the tubes can be measured and then computed into volume, and then the volume is multiplied to that of a drop, and we thus know how many globules there are in a drop.

31. Relative Size of Globules.

We have given the size of globules with a suggestion that they are not all of the same size. They are larger in the milk of some breeds of cows, and are much more numerous and smaller in the milk of strippers than in that of fresh cows.

Succulent food also decreases the size as well as increases the number.

The globules are larger in the strippings than in the fore milk. While some breeds of cows as the Jerseys and Guernseys give rich milk and have, comparatively speaking, large globules, richness of milk does not necessarily control the size of the globules, for the factors mentioned above, as period of lactation for instance, may change this.

The large globules have 67 times greater bulk than the smaller ones, and are 250 to 300 times greater in weight. This fact has an important bearing on the creaming of milk as will be explained later.

Perhaps the average diameter of milk fat globules is 1-10,000 of an inch. The following sizes of fat globules according to breeds are given by the Geneva, N. Y., Experiment Station:

Holstein	$\frac{1}{12090}$
Ayrshire	$\frac{1}{12450}$
Devon	$\frac{1}{10370}$
Guernsey	$\frac{1}{9350}$
Jersey	$\frac{1}{9630}$

32. Per Cent. of Fat in Milk.

The per cent. of fat in milk means the number of pounds of fat in one hundred pounds of milk. The fat is the most variable constituent of the milk and it would be difficult to make an exact statement of what the average fat test is in cow's milk. Dr. Babcock finds that it is 3.7% when Wisconsin cheese factory and creamery milk is concerned, and Dr. VanSlyke finds that New York conditions give about the same results.

The percentage usually increases with the length of the period of lactation, with possibly a slight drop the second or third month when the flow of milk is greatest. The fifty animals at the Geneva Experiment Station which were averaged according to months of lactation for solids were also averaged for butter fat as follows:

Month of Lactation.	Average Per Cent. Fat.
1	4.54
2	4.33
3	4.28
4	4.39
5	4.38
6	4.53
7	4.56
8	4.66
9	4.79
10	5.00

33. Effect of Breed.

Breed also affects the fat content of the milk. Holsteins are noted for the large quantity as well as thin milk that they give, while Jerseys give less but richer milk.

In the Geneva breed test previously mentioned the average, low, and high tests for each breed are given:

GENEVA STATION BREED TEST.

	AVERAGE PER CENT. OF FATS.		
Breed.	Average.	Low.	High.
Holstein	3.36	2.88	3.85
Ayrshire	3.60	3.20	4.24
Devon	4.60	4.30	5.23
Guernsey	5.30	4.51	6.13
Jersey	5.60	4.96	6.09

34. Strippings Compared With Fore Milk.

It has been stated that the elaboration of milk occurs in the epithelial cells of the alveoli. The fat globules are formed there and the cell walls breaking down, they are discharged into the cavity of the alveoli, and find their way down the milk ducts into the teat. But as they are solid bodies and rub along the walls of the milk ducts, they do not travel as fast as the milk serum (some authorities think they are not elaborated as rapidly) and the result is that the last of the milk or the strippings, as it is called, is much richer in fat than the fore milk.

Successive samples taken during a milking have been shown to test .9%, 2.6%, 5.35% and 9.% fat. The thoroughness then with which the udder is emptied, affects the fat content of the milk given. While it is not always true, it is usually the case that short periods between milkings produce richer milk than long periods.

Attention has already been called (15) to the fact that some milkers can get more and richer milk than others from the same cows. This may be due to method of milking and agitating the udder, and it is possible that the cows like certain milkers better and give their milk down better.

35. Effect of Excitement of Cow.

Professor Woll has called attention to the fact that sickness with fever or excitement will cause smaller fat globules, and perhaps the amount secreted may be affected.

We give a few instances that have come to our observation:

It was the privilege of the author to operate the Babcock milk test the first time that it was exhibited outside of Madison. This was at the Portage and Baraboo Fairs, September, 1890. The Hon. John M. True was president of the Baraboo Fair and lived on a farm adjoining the fair grounds. He had a grade Jersey cow called Daisy which he brought onto the grounds to be tested. She was milked at six in the evening after the day's excitement on the grounds, and again in the morning at home, under normal conditions, at six o'clock, with the following results:

DAISY TRUE AT BARABOO FAIR.

Time Milked.	Pounds Milk.	Per Cent. Fat.	Pounds Fat.
Six p. m.	21.75	6.5	1.41
Six a. m.	19.38	5.4	1.05
Totals	41.13		2.46

It will be observed that after the day's excitement she gave more and richer milk than in the morning after quieter conditions. The record for the day was an exceptionally good one and if kept up for a week would make 17.22 pounds of fat, which would probably produce twenty pounds of butter. It was therefore decided to make a week's test. The results as compared with the day at the fair were:

	Milk. Pounds per day.	Per Cent. Fat.	Pounds' Fat per day.
Poorest day	38.5	3.99	1.81
Best day	44.5	5.16	2.19

The Hon. John M. True's cow, Daisy, shown at the Baraboo, Wis., Fair, 1890.

The total fat for the week was 13.81 pounds and the best test and best day's fat did not come up to the test of the day at the fair. But she did well enough to have her photograph taken, and it was desirable to have the picture taken with the udder full, so instead of milking at six in the morning as usual, the picture was taken at nine when the light was sufficient, and the animal much to her dislike, was separated from the other cows. Then came the milking and she gave 28.25 pounds of milk testing 6.33% fat, the highest record made by her. Elaborating a little over a pound and a half of milk per hour during the previous week, it was wholly unexpected for her to give eight pounds extra for three hours extra time, and the butter fat was still more of a surprise.

36. Effect on Fat of Showing at Fairs.

We also give another instance of excitement, working in this case to the detriment of the results. Two Holstein-Friesian cows belonging to Gillett & Son of Rosendale, Wisconsin, were tested first at home, again the next week at the Fond du Lac County Fair, third at the State Fair at Milwaukee, and following that went to the Indiana State Fair, and the fifth week tests were reported from the Illinois State Fair:

The results were as follows:

	Rijanetta.			Duchess of Springvale Fourth.		
Where Tested.	Pounds Milk.	Per Cent. Fat.	Pounds Fat.	Pounds Milk.	Per Cent. Fat.	Pounds Fat.
At home	60.38	2.52	1.52	34.63	2.75	.96
	59.94	2.83	1.70	33.01	2.99	.96
				33.00	3.16	1.04
At Fon du Lac	57.25	2 73	1.56	33.60	3.33	1.13
	53.80	3.10	1.67	32.50	3.04	.99
At Milwaukee	56.30	3.18	1.79	33.00	3.37	1.11
	53.00	3.15	1.67			
At Illinois State Fair	39.00	1.84	.72	26.00	1.10	.12

The trip to Indiana was very hard on the cows and they were said to have arrived at the Illinois Fair much exhausted. An interesting question arises; did the milkers get all of the milk elaborated? If not, the shortage of milk and butter fat is easily explained by saying that the strippings were left in the udders. The milkers, however, seemed to think that the cows did not elaborate any more than was drawn from the udder.

37. Highest Testing Normal Milk.

After thirteen years experience with the Babcock test, in which time we have tested thousands of samples of milk, the richest sample in butter fat, of which we were sure that it was a fair sample of the whole milking, tested 10.7% fat.

The cow did not give this amount regularly, but dropped at the next milking. In but a few cases have we found milk testing nine per cent., and it is a rare thing for a cow to average seven per cent.

The subject of testing cows will be discussed in a later chapter of this book.

CHAPTER V.

Milk Solids not Fat.

38. Ash.

The ash of the milk is the mineral matter that is left after burning off the organic matter. It contains all of the mineral matter necessary to build up the bony frame work of the growing young animal.

The milk is a very complex substance and it is very difficult to determine just how all of the mineral elements are combined. The following chemical elements go to make up the ash: Calcium, sodium, potassium, magnesium, iron, phosphorous and chlorine. Calcium and potassium phosphates are present, and the former is supposed to be combined with the casein. Some of the ash is soluble and part is in little particles held in suspension, for it can be filtered out in a porcelain filter or thrown out in a separator bowl, which would not be true if it were all in solution. The ash seems to be quite uniformally present in cow's milk to the extent of about .7%. If we had as much data about the ash as about the butter fat we might not be able to speak as positively about it.

Rennet, the ferment from the calf's stomach, which is used in making cheese, will not coagulate the milk if the soluble calcium (lime) salts are absent.

39. Proteine Compounds.

The proteine compounds are those which contain nitrogen, and a little sulphur and phosphorous. It is

found in the form of two substances; caseine, the cheese part, and albumen.

40. Caseine.

The caseine consists of carbon 53%, oxygen 22.7%, hydrogen 7%, nitrogen 15.7%, phosphorus .85%, and sulphur .75%. It is not in solution but is in a colloidal state much like starch held in hot water. This is proved by filtering it out of the milk by means of a porcelain filter, and by throwing it out by whorling the milk for a long time in separator bowl. Dr. Babcock discovered this latter method and separated the caseine that he studied, in a Danish Weston separator bowl. The substance deposited on the walls of the bowl was a milky slime. When dried on glass it became transparent with a flourescent appearance.

The results of one of Dr. Babcock's experiments was as follows:

	Per Cent. Solids.	Per Cent. Nitrogen.	Per Cent. Ash.	Per Cent. Ash in Dry Substance.
Skim milk diluted with equal water	4.25	0.24 =1.53 proteine	.396	9.32
Liquid after 3 hours whorling.............	3.25	0.12	.283	
Total substance removed in 3 hours............	1.00	0.12	.113	8.04

This table shows that a substance containing nitrogen was thrown out and with it some ash, and Dr. Babcock concluded that the ash or at least a portion of it was not in combination with the caseine.

41. Caseine and Albumen, How Separated.

Caseine is coagulated by rennet and dilute acids, but not by ordinary heat. Caseine is precipitated by heat of 265° F., which is secured only under pressure, while the albumen is coagulated by heat and not by rennet or acids.

If after coagulating milk with either rennet or dilute acids the whey is heated to 180° F., a white precipitate (which is the coagulated albumen) is thrown down.

The proteine substances, both caseine and albumen, increase in the milk with the period of lactation. The following table compiled by Dr. VanSlyke shows this increase:

Table showing effect of period of lactation upon the per cent. of caseine and albumen in milk:

Month of Lactation.	Per Cent. Proteine.	Per Cent. Caseine.	Per Cent. Albumen.
1	3.00	2.45	.55
2	2.96	2.45	.51
3	3.08	2.51	.57
4	3.10	2.48	.62
5	3.10	2.55	.55
6	3.75	2.65	.92
7	3.66	2.91	.75
8	3.77	3.00	.77
9	4.03	3.15	.88
10	5.05	3.66	1.39

There is usually three and a half times as much caseine as albumen in cow's milk.

42. Milk Sugar.

Milk sugar, or lactose, forms one-third of the solids of the milk, and more than half of the solids of separator skim milk. It is less sweet than beet or cane sugar, and is obtained commercially from the whey at cheese factories.

43. Sugar, How Obtained.

An easy experiment can be made by first coagulating a quart of skim milk with rennet or acid. Strain out the curd and then heat to the boiling point and the albumen will be precipitated. Let this settle and decant the clear liquid or filter it and then boil the clear liquid to dryness. The milk sugar and ash will be left behind

in the form of a white powder. Milk sugar has not been studied as much as the fat and caseine, but it is reported to vary from three to six per cent., with an average of five per cent. It is a carbohydrate and is valuable in whey or skim milk for feeding to calves or pigs.

CHAPTER VI.

THE PHYSICAL PROPERTIES OF MILK.

44. Physical Condition of Milk.

We have seen in the preceding chapters that milk consists largely of water in which are dissolved the sugar, most of the ash and the albumen, while the caseine is held in a colloidal state and some of the ash in suspension. This forms the milk serum (same as separator skim milk) in which the fat is held in emulsion.

45. Specific Gravity.

If we take a barrel that will just hold 1000 pounds of water at a temperature of 60° F. and fill it with milk serum, we will find that the barrel will hold approximately 1036 pounds, and we say that the skim milk, or milk serum, has a specific gravity of 1.036.

If we fill it with butter fat at 60° F. less than 1000 pounds or 930 pounds will fill it, and it has a sp. g. of .93. The fat in whole milk being much lighter than the other solids reduces the specific gravity to perhaps 1.032. The lowest specific gravity of pure milk that has been found was 1.029.

If the temperature of the substance in the barrel be raised, for each degree approximately one-tenth of a pound will run over the top, caused by the expansion. If the temperature be lowered, the milk will contract so that for each degree, approximately one-tenth of a pound more may be put into the barrel.

46. Lactometer.

An instrument known as the lactometer, being a weighted glass bulb with a long stem at the top upon which is written a scale, just floats in water of 60° F. to the zero mark. In milk of 1.032 sp. g. it is bouyed up until it reaches the corresponding point on the scale. By means of the lactometer the specific gravity of milks can be obtained. Both butter fat and water when added to milk reduce the specific gravity.

When the right amount of water is added to separator skim milk, the lactometer which does not distinguish the difference between fat and water, but simply shows that it is lighter, might lead us to believe that the milk is pure when the facts are, that it is both skimmed and watered. If we call the Babcock test to our aid it will tell us whether the fat is there, and by using both instruments we can readily determine the adulteration.

47. Creaming of Milk.

The fat globules, being lighter than the surrounding serum, have a tendency to rise by the action of the force of gravity. If we take a glass cylinder or bottle, and fill it with soap solution and shake it to incorporate air, and then set it down, the air bubbles will rise to the top forming a lather (or cream). It will be observed that the large bubbles rise much faster than the smaller ones. The air in the bubbles is all the same kind of air. In like manner the large fat globules rise faster than the small ones. It is not because the fat in the large globules is any different than in the small ones. Actual analyses of the fats have shown them to be identical in every way.

48. Viscosity.

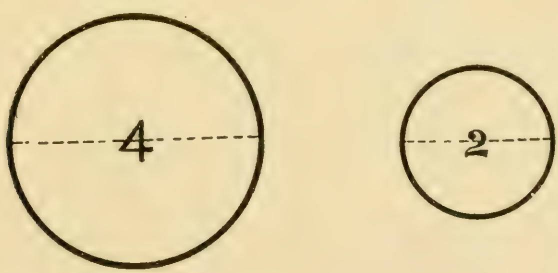
The milk serum is slightly viscous, or sticky, like molasses, and the colder it is the more viscous it be-

comes. Skim milk at the freezing point may become so viscous that it can be whipped up into a froth. This stickiness of the milk serum holds the fat globules back like a brake, or they would quickly form a layer of pure fat on the top. The large fat globules have less surface than the small ones in proportion to their cubical contents, and consequently the difference between upward gravity pressure and the brake pressure is greatest in the large globules.

49. Law Governing Creaming.

The law that governs this physical phenomenon is stated as follows: The surfaces of two spheres are to each other as the squares of their diameters, while their cubical contents are to each other as the cubes of their diameters.

For example: Suppose we have two spheres, one two inches in diameter and the other four—



Their squares would be 16 and 4.

Their cubes would be 64 and 8.

While the four-inch cube is twice the diameter, its surface is four times and its cubical contents eight times that of the smaller one. Applying this law to two fat globules of the same proportion, we can see that while the large globule is forced up with eight times the pressure of the smaller one, it is retarded by only four

times the force, and consequently rises faster in that proportion.

50. Definition of Cream.

Cream is a portion of the milk serum into which the fat globules have been crowded.

If the fat globules are pushed close together it is a rich cream, but if they are farther apart it is a thinner cream.

Cream may test only 10% or 15% fat, or it may test 60%. Ordinary gravity cream runs from 18% to 25%, while a centrifugal separator can be set to take cream testing anywhere from 15% to 60%.

Cream contains all the elements of the milk serum, and they are present in inverse proportion to the amount of fat present. If the cream tests 50% fat the amount of serum elements will be just half as much as in the separator skim milk.

51. Effect of Temperature Upon Creaming.

We have found that as the temperature of the serum is lowered, it becomes more viscous and we may expect it to retard the rising of the fat. There is another factor which steps in here. At about 50° F. the fat seems to take on a harder condition, so that the globules slip through the serum much more readily. Thorough separation of the cream cannot be obtained at temperatures above 50° F. As well water usually comes from the ground at temperatures higher than 50°, exhaustive creaming cannot be obtained by setting the cans of milk in such water. For effective gravity creaming, ice water (which, of course, means not warm water with a little ice in it, but water cooled to 40° F. with ice) is absolutely necessary.

The milk in the can begins to drop in temperature, the colder milk falling to the bottom, until all of the milk reaches the temperature of the water.

Below are given the results of deep setting experiments, one case being where the milk was set in ice water at 40° and the other in water at 60°.

Table showing progress of creaming of milk at 90° F. set in water at 40° and 60°. Samples were taken from the bottom, middle and top of milk just below the cream line:

Time from Setting.	Section of Can.	Set in Water 40° F. Per Cent. Fat in Milk.	Set in Water 40° F. Temperature of Section.	Set in Water 60° F. Per Cent. Fat in Milk.
	Top	5.0	72°	4.48
15 minutes	Middle	5.0	69°	4.50
	Bottom	4.95	56°	4.40
	Top	4.95	60°	4.50
30 minutes	Middle	4.90	57°	4.40
	Bottom	3.60	49°	4.45
	Top	3.40	54°	....
60 minutes	Middle	3.20	52°	4.50
	Bottom	1.95	46°	3.92
	Top	3.60	50°	5.20
2 hours	Middle	3.00	47°	3.90
	Bottom	1.05	42°	....
	Top	1.55	45°	3.55
4 hours	Middle	1.35	45°	3.00
	Bottom	.65	41°	2.30
	Top	1.20	45°	3.00
5½ hours	Middle	1.10	45°	2.95
	Bottom	.55	43°	2.18
	Top	....	...	2.45
15 hours	Middle	....	...	2.30
	Bottom	....	...	1.20
	Top	.50	44°	.40
36 hours	Middle	.45	44°	....
	Bottom	.20	44°	....

The above table shows that much better creaming was done in ice water in five hours than in water at 60° in three times that length of time. It also shows that

something is to be gained even in ice water by leaving it as long as 36 hours.

In experiments reported at the Cornell, N. Y., Experiment Station, Cooley cans set in ice water showed a loss of .28% when set in water at 60° F.

52. Shallow Setting.

In shallow pans where the fat does not have as far to rise, when set in air at 60°, the loss was .48%. When cotton seed meal is fed to cows, the temperature at which equal effectiveness is secured is four or five degrees higher (22).

53. Dilution Creaming.

In 1892 there was an open winter when but little ice was harvested, and dairymen were compelled to use some method of getting the cream out of the milk. It was suggested that the milk be diluted to reduce the viscosity.

The fact that the specific gravity of the serum was also reduced seems not to have been considered. A cream line will form very quickly by this method, and the depth of the cream being considered, the dairymen concluded that they got it all. The facts are that such cream tests from 7% to 15% fat, and the greater part of the fat is left in the skim milk. Even after leaving the milk to set for 24 hours, 25% to 35% of the butter fat still remains in the watered skim milk. Since 1893, up to the present time, a great many dilution creamers under different names have been sold, the manufacturers often grossly misrepresenting their efficiency. Professor Wing of Cornell published two bulletins exposing the fraud. In these bulletins he reports experiments which show the losses, where both hot and cold water was used for dilution, to have been 1.11% to 1.28% fat.

Where hot water is used the cream gets rancid quicker, making an inferior quality of butter, and the diluted skim milk is of inferior feeding value. The cream being thin causes great losses of fat in the butter milk.

54. Creaming Under Air Pressure.

In 1891, a contrivance known as the Berrigan separator was brought out, in which the milk was placed under an air pressure of thirty pounds to the square inch for a short time. It was claimed that the fat would all rise to the top very quickly. Repeated trials at the Wisconsin Experiment Station and at Cornell proved that there was nothing in the claims made for the device.

55. The Centrifugal Separator.

When a pail of water is swung over the head, the water though in a pail upside down does not fall out. The centrifugal force thus created is stronger than the force of gravity. When a liquid is revolved in a perpendicular cylinder it is thrown up against the walls of the cylinder on account of the centrifugal force, and the faster the cylinder revolves the greater is the force exerted. In the case of milk in the separator bowl, the fat being lighter than the serum, is thrown against the walls of the bowl, but is not thrown with as much force and soon forms a cream line on the inner surface of the liquid. If the bowl is constantly filled to overflowing, the liquid must flow out at the same rate. A little opening allows the cream to escape and it is caught in a pan surrounding the bowl as it flies off. The skim milk is freest from fat globules near the peripheral walls of the bowl, small tubes leading to the top and near the center of the bowl allow the skim milk to flow out from this point. Changing the relation of the skim milk

and cream outlets, with reference to their distance from the center, will regulate the proportion of cream taken and consequently its richness in fat. By carrying the cream outlet nearer the center, the fat globules are crowded closer together before getting out. Turning it farther from the center makes a thinner cream.

The various devices in the bowls of the different makes of separators are to make the milk travel a longer distance before getting out, and thus increase the capacity. The best machines on the market will skim up to the capacity claimed, taking cream testing 40% fat and leave not over .05% fat in the skim milk. The machines should do this with milk at a temperature of 90° F. In buying a machine the salesman should be asked to guarantee the machine to do these things.

56. Factors Affecting Centrifugal Separation.

The efficiency of a separator is affected by the speed of the bowl, the temperature of the milk, and the rate at which the milk flows through it. The thickness of the cream will be affected by the adjustment of the cream screw, the temperature of the milk, the rate of flow of milk through the bowl, and the speed of the bowl.

57. Durability of Separators.

The life of a machine depends, of course, upon the construction of the machine, and likewise upon the care it receives. Dirt and poor oil, and harsh handling will wear out a machine in short order when it might otherwise last a long time. The expense of a machine is not so much in the cost of material, as in the skilled labor in its manufacture, The bowl has to be turned, tinned, and carefully balanced.

58. Theory of Churning.

A theory was formerly current that the fat globule was enveloped in a membrane which was broken in churning, but no one has ever seen such a membrane, and many people have seen under the microscope the soft fat globules running together. If the temperature is high enough that the fat is soft and pasty, the "butter comes" quickly. On the other hand if the temperature is below 50° F., the butter will not churn. Our grandmothers used to drop a red hot horseshoe into the cream to drive out the witches and the butter would come—simply because the fat was warmed up enough to make it soft enough to stick together.

59. Varieties of Churns.

A great many churns have been patented and placed upon the market, with the claim that they will bring butter in five minutes. Among these churns are a number of machines going under the enticing name of "butter separator," of similar construction, in which a turbine wheel inserted in a vessel of wood, stone or metal draws a current of air down a hollow shaft into the cream. It is claimed that the air oxidizes and does many things unknown to chemists, eventually separating the butter in five minutes. When the air shaft is closed with a cork the device works just as well without the air, and the time for churning increases as the temperature of the cream or milk is lowered. Of the many churns invented none is better or more efficient than the common box or barrel churn.

60. Effect of Temperature Upon Churning.

When the temperature of the cream is high enough to make the butter come in five minutes, the fat is so

soft that the butter is soft and the grain becomes greasy and salvy in handling, salting and working.

Quick churning is, therefore, at the expense of the quality of the butter. Cream churns best—that is, the most exhaustively and makes the best grained butter, when the cream is rich in fat (35%) and the temperature low (but little above 50° F.). When cream is thin, the large fat globules strike and accumulate into granules before the smaller globules have a chance to come into contact with other globules. The result is that there is not only a large amount of butter milk in which to lose fat, but it is richer in fat.

61. Advantage of Rich Cream.

By having the cream thick, the globules of fat are brought so close together that the small globules must strike other globules. By churning at a low temperature when the fat is harder, the time of churning is extended, giving the small globules a longer time in which to get a chance to adhere. The result is that there is less butter milk in which to lose fat, and the fat test of it is low. If the cream is very thin, it will be found necessary to raise the temperature to such a point, that the globules will be soft enough that when they do strike they will adhere. It is sometimes found necessary to raise the temperature of thin cream to 65° F. in order to get the butter to come at all.

62. Churning Cream From Strippers' Milk.

In case of stripper cows when the fats are harder or where cows have been fed on cotton seed meal, thus hardening the fat, it is necessary to raise the churning temperature.

63. Reason Cream Thickens Before Breaking.

Cream will thicken in the churn just before the butter comes. If the cream is rich in fat, 40% or above, it will become so thick that it will not drop in the churn, and it is necessary to thin it up with water in order to continue churning. The fat globules that at first had room enough to pass each other, begin to stick together, and their rough edges stick out against each other so that they cannot pass, and the whole mass of them being unable to move past each other makes the cream a mass that will not drop in the churn. The addition of water gives them a chance to pass.

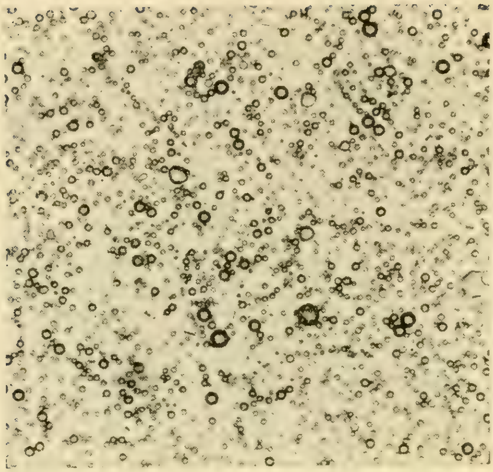
We may conclude from these conditions that cream should be about 35% fat for best results in churning. Richer cream will stick in the churn, and thinner cream gives more butter milk in which to lose fat, and the percentages of fat are higher, as borne out by experiment.

64. Viscosity Affected by Condition of Fat.

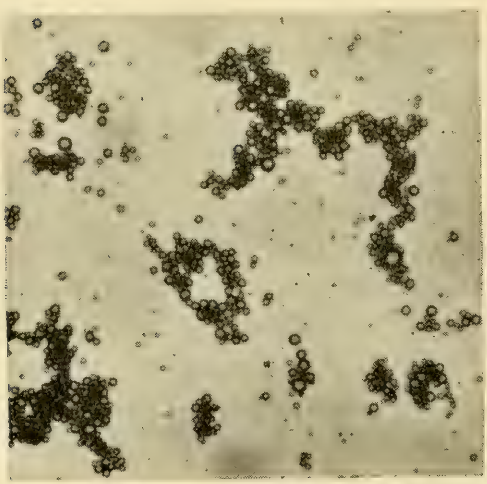
We have seen that before the cream breaks into butter in the churn, it becomes thicker, and that this is because of the grouping of the fat globules.

Cream raised by the gravity process appears thicker, or more viscous, than separator cream of the same fat content. Cream pasteurized at temperatures above 140° seem thinner than before pasteurization, and milk pasteurized above 140° F. sometimes fails to show a cream line. The microscope has revealed the cause.

In the gravity creaming, and in milk that stands, the fat globules at first separated from each other begin to collect in little groups, and the ferment galactase probably clots some of the proteine around them, binding them together.



The fat globules as seen under a microscope where cream or milk has been pasteurized above 140 deg. F.

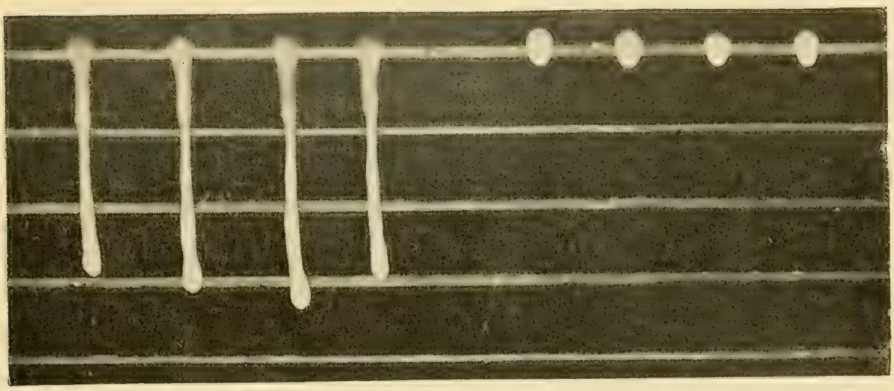


The fat globules as seen under a microscope, where milk or cream has not been pasteurized above 140 deg. F., or where viscogen has been added.

In passing through the centrifugal separator or in heating above 140° F. these clots are broken up. It has already been pointed out that large globules in milk rise faster than the smaller ones. In like manner groups of globules rise faster than single ones. If the groups are broken up by pasteurization, a cream line may not form even though all of the fat be present.

65. Viscogen.

The greater viscosity of gravity and unpasteurized cream is caused by the fat globules elbowing each other and making the whole liquid appear thicker. Anything



Cut from Wisconsin Experiment Station Report, showing a glass plate on which drops of cream have been placed and the glass then inclined. The drops in which there was no viscogen ran down the plate, while the ones treated with viscogen did nct run.

that will restore the grouping of the globules will restore the viscosity. Drs. Babcock and Russell have suggested the use of sucrate of lime for this purpose. It is prepared as follows: Two and one-half parts of cane sugar are dissolved in five parts of water. One part of unslaked lime is put into three parts of water. The whitewash and sugar solution are then mixed thoroughly (in a barrel churn) and agitated occasionally for two or three

hours and then allowed to settle. The clear liquid on top is called viscogen. When added to cream the fat globules are formed into groups and the cream is thereby made more viscous.

66. How to Use Viscogen.

Viscogen is alkaline in reaction and if too much is used, the cream will have a disagreeable odor. It is perfectly harmless as used in cream, but should not be used unless the customer is made aware of the fact by a proper label on the package. If called "Visco cream" it becomes a distinct article under that name. If sold just simply as cream, it could be considered an adulteration.

To use the viscogen, take a pint of milk and a pipette or burette, graduated to tenths of a cubic centimeter. Gradually run the viscogen into the cream, stirring it in. Have a 10% solution of phenolphtalein in alcohol and pour a few drops on a white paper. With a glass rod place a drop of cream on the indicator solution (phenolphtalein). As soon as the acid of the cream has been neutralized by the alkaline viscogen the drop of cream will turn pink.

If it took four cubic centimeters of the viscogen to neutralize a pint, or pound, of cream, 400 c.c. would be required to neutralize 100 pounds. But if enough is used to entirely neutralize the cream, the disagreeable odor will appear. Use half or two-thirds the quantity necessary to neutralize and the viscosity will be increased and the flavor improved.

67. Whipping Cream.

The whipping of cream depends upon its viscosity. The viscosity depends upon the solids not fat as affected by temperature, and by the fat globules.

Skim milk can be whipped into a froth at the freezing point. This shows the effect of the solids not fat on viscosity, apart from the effect of the fat globules. Thin cream thickens as it sours. This is because of the formation of caseine clots and the grouping of fat globules. Housewives often try to whip cream of 20% fat content without success, because it is not cold enough. Glass is a poor conductor of heat and a glass bottle that has been "against the ice for twelve hours" may contain cream of a temperature as high as 50° F. Such cream may whip nicely at 32°, but not at 50°. Cream of 30% fat will whip nicely at 50° F. when 20% will not, and 40% will whip still better. Ageing cream allows the fat globules to gather in groups, when it will whip more readily.

68. Beaten Cream.

Beaten cream is made from rich cream whipped at a churning, or just a little lower temperature. The beaten appearance is made by the butter granules when they are very fine, but cannot be discerned as butter. It is cream in just the same condition as in the churn just before the butter comes.

69. Skim Milk.

Skim milk is milk from which a portion of the fat has been removed. The fat of whole milk is usually one-third of the total solids. The Ohio law says that it must be at least one-fourth of the total solids. The fat may be removed by either the gravity or centrifugal methods. The centrifugal machines will remove all but a trace of the fat, but no machine made will skim absolutely clean. The microscope will still show a few very small globules of fat. At the Cornell Experiment Station a number of

tests of different methods of creaming were made with average results, as follows:

Method of Creaming.	Milk Test, Per Cent. Fat.
Whole milk used	4.24 %
Cooley cans set in water 40° F......	.29 %
Centrifugal separator	.09 %
Dilution creamer	.59 %
Cooley cans in water at 60°........	1.00 %

At the Wisconsin Station cold deep setting was compared with the centrifugal method as follows:

	Loss of Fat in Pounds Per 100 Pounds Milk Set.				
Lot	1	2	3	4	5
Deep setting	.148	.257	.239	.245	.382
Centrifugal separator.	.107	.109	.110	.100	.129
In favor of centrifugal separator	.041	.148	.129	.135	.253

Skim milk contains all of the solids of the milk except the fat which has been taken out, and is, therefore, of great feeding value.

70. Butter Milk.

Butter milk is the same in composition as skim milk though it is usually sour. The butter fat has been gathered out by the process of churning, leaving the other solids of the milk behind.

71. Artificial Butter Milk.

A growing demand for buttermilk in cities is met by souring whole milk or skim milk and churning it to break up the coagulated caseine. Whole milk is used so that a few butter granules may be present to announce to the consumer that it is real buttermilk.

CHAPTER VII.

Butter and Cheese.

72. History of Butter and Cheese.

The dairy business is of ancient origin. Abraham (Genesis, 18:8) is said to have put butter, milk and a dressed calf before his guests. Jesse sent David to the camp of the army of Israel with ten small cheese, about three thousand years before the days of daisies, Young Americas, longhorns and ten-pound prints. It is recorded in Proverbs 30:33 that "the churning of milk bringeth butter."

The dairy business in the great continent of Asia cannot have progressed much since those days, for the milk is still churned by being dragged at a rapid rate in a skin pouch behind a horse, and a lady writing from Sidon, Syria, says that clarified butter is boiled and skimmed, and that she does not "indulge." The inhabitants of the great Thibetan plateau have butter as a staple article of trade. They not only eat it, but smear it on their faces and bodies to make them shine, beside burning butter in lamps. Dr. Susie J. Rinhart, in her intensely interesting book, "With the Thibetans in Tent and Temple," tells of people gathering from all over Western China, Mongolia, and Thibet to the "Festival of the Butter God." This occurs annually.

An image of Bhudda twenty feet high carved out of butter, with smaller butter idols and butter lamps were the center of attraction.

The heat from the lamps finally melted the gods which were thrown out into a ravine to be devoured by dogs and vultures.

American creamery butter packed in sealed tins is now reaching the orient, and the sleeping giant may yet awake to higher ideals of the quality of first-class dairy products.

73. Butter.

Butter is not pure fat. It is a mixture of milk fat, water, salt, and caseine. An analysis of average butter will probably show:

Fat	84 %
Water	12 %
Salt	3 %
Caseine	1 %

Like other dairy products, butter will vary in its composition within certain limits.

When cream is churned, the fat gathers into granules, the buttermilk is drained out, and in order to get rid of the milk serum further, it is washed. Some curdled caseine will be left behind. This may be less than half a per cent. or it may be considerably more. It is desirable to get rid of it as completely as possible, as it damages the keeping qualities of the butter. Salt is added, a large part of which dissolves and runs off in the form of brine. Wherever the salt strikes the butter, it deepens the color, and if the salt is not evenly distributed, it will cause the butter to be streaked and mottled. To distribute the salt, the butter is worked over and pressed together, and in so doing water between the particles is expelled.

74. Over-run.

By careful skimming, and by close churning, and careful working of the butter, it is possible to get one-sixth over-run; that is, one-sixth more butter than the fat in the milk, but the usual results are one-tenth to one-eighth more.

It is seldom that as much as 16% water can be incorporated into the butter, and it usually runs between 11% and 13%. It is impossible to get an over-run of 25% of marketable butter.

If a butter maker says he gets 25% over-run one of three things is true; either it is not good butter, he has read his fat test too low, or he misrepresents.

75. Renovated Butter.

A large portion of the butter made in the United States is made on farms under unfavorable conditions. While some dairy butter is of first quality and compares favorably with creamery butter, it is as a class poor. It is sold at country stores in exchange for groceries, and becomes very rancid and foul smelling. It is brought together into large quantities and bought up by process men and renovated. It is melted up and put through a deodorizing process, is granulated and churned in ripened milk, and made into butter. Much of this has in the past been sold for creamery butter. The law passed by Congress, which went into effect July 1, 1902, putting a tax of ten cents per pound on oleo colored yellow like butter, also put a tax of ten cents on this material and called it "renovated" instead of "process butter," and requires that each package be marked "Renovated Butter." A heavy fine is imposed for the violation of the same. Canada prohibits its manufacture. Any creamery man who works over a bad batch

of butter by remelting and rechurning it, is liable to a heavy fine, as this may be classed as renovated butter.

The process men claim that an injustice has been done dairy farmers by the enaction of this law, as the process men made a way for them to get rid of their poor butter.

But the public was being imposed upon, and the farmer who was making poor butter was losing money by so doing, and at the same time the process business kept a bad thing going.

These are days of coöperative industry. The farmer should unite with his neighbors in securing a skilled operator to turn his cream into butter at nearly double the price of poor country butter, and he himself should give better attention to producing good milk and cream from which to make first-class butter.

The oleo fraud was taking the field of 1600 average creameries in 1901. People do not want fraud—they want a good article. Poor butter forced some people to eat oleo. Most people were deceived by the color. They do not want uncolored oleo, as shown by the revenue statistics of 1902-3, when fifty-three million pounds less oleo was made than in the previous year. It would take 650 creameries to make that much butter.

76. Cheese.

Cheese of the different varieties is made by coagulating the milk with rennet, a ferment from the calf's stomach, and then cutting the curd into small pieces, from which the whey, which is the water of the milk with the soluble ash, sugar and albumen, exudes. The fat globules are caught in the coagulum, but a few globules are knocked off from the surfaces of the curd particles into the whey. The curd contracts until it becomes quite

firm, and is removed from the liquid whey. The whey is of the same composition as skim milk, minus the caseine.

The richer the milk is in fat, the more and richer cheese it will make.

77. Food Value of Cheese.

Cheddar cheese made from average full cream milk is composed as follows:

Water	37 %
Fat	34 %
Caseine	24 %
Ash, etc	5 %
	100 %

Meat Contains—

Water	50 % to 75 %
Proteine	15 % to 20 %
Fat	15 % to 20 %
Ash	1 % to 3 %

It will thus be seen that cheese contains twice as much food value as meat, and a pound of cheese can usually be purchased for less money than a pound of meat; 95.55% of cheese is absorbed in the digestive tract.

78. Yield and Quality of Cheese as Affected by Milk.

If the fat is less than the other solids of the cheese it was made from skimmed milk, or its equivalent, of very poor milk. It is really a matter of the ratio between caseine and fat as shown in the following table:

No. Samples Analyzed.	Per Cent. Caseine.	Per Cent. Fat.	Pounds Fat for Each Pound Caseine.
68	2.80	2.30	.82
135	2.78	2.62	.94
278	2.86	2.86	1.00
224	2.89	3.02	1.04
337	3.09	3.53	1.14
364	3.27	4.02	1.23
216	3.52	4.54	1.29
152	3.54	4.92	1.38

An average of 5500 samples of milk reported by Dr. VanSlyke of fat tests between 3% and 5% showed:

Total solids, 12.29%; fat, 3.92%; proteine, 3.2%, or about the same as given in the chart in Chapter II of this book. The ratio between caseine and fat was 1 : 1.225.

The effect of this ratio on the yield and quality of cheese is shown in the following table, the richer cheese being correspondingly better in quality, and worth more money per pound.

Table showing the results of the milk fifty herds of cows made into cheese:

Per Cent. Fat in Milk.	Per Cent. Caseine.	Pounds Fat for Each Pound Caseine.	Yield of Cheese per 100 Pounds Milk.	Per Cent. Fat in Cheese.
3.00	2.10	1.43	8.85	32.2
3.25	2.20	1.48	9.10	32.9
3.50	2.30	1.52	9.60	33.9
3.75	2.40	1.56	10.10	34.7
4.00	2.50	1.60	10.65	35.2
4.25	2.60	1.63	11.20	35.7
4.50	2.70	1.67	11.70	36.3

Skimming out the fat lowers the ratio between caseine and fat, and the cheese made from the 3% milk is like a light skim cheese. Under date of May 11, 1903, the New York cheese market quotations were as follows:

Full creams	11@11 3-8c
Light skims	9c
Part skims	6@7c
Fair to good skims	5@6c
Common skims	3c
Full skims	2c

The cheese made from 3% milk contains 32.2% of fat and compares to a light skim cheese, while that made from milk testing 4.5% fat will bring the highest market price.

8.85 lbs. cheese @ 9 cts. =	79.65 cts.
11.70 lbs. cheese @ 11.3 cts. =	145.43 cts.
Difference in price of 100 lbs. milk	65.78 cts.

The above figures illustrate that the method of pooling all qualities of milk at a cheese factory at the same price per hundred pounds is very unjust.

The term "full cream" is used to indicate that the milk used in the manufacture was full cream—that is, had had no cream taken from it. From this the impression has gone out that "cream" cheese is something extra fine. Although a fine grade of cheese can be made from milk to which cream has been added, this is never practiced. The tendency as has been explained, is rather to take cream out.

CHAPTER VIII.

Contamination of Milk.

79. Flavor of Milk, How Affected.

Upon standing, milk begins to decompose and take on different odors.

There are said to be three ways in which milk may take on odors.

First. By the food the cow eats. Cows eating onions or garlic in large quantities have shown the characteristic odor in their flesh when slaughtered immediately after. There is no doubt but that such flavors get into the milk. Professor F. H. King conducted some experiments at the Wisconsin Experiment Station from which he drew the conclusion that in order to detect the odors, the strong flavored foods must be fed within two hours before milking.

Second. By absorption. Milk, especially when warm, will absorb bad odors. It has been suggested that perhaps the strong flavor due to food was not carried through the cow, but through the air, and is after all a matter of absorption.

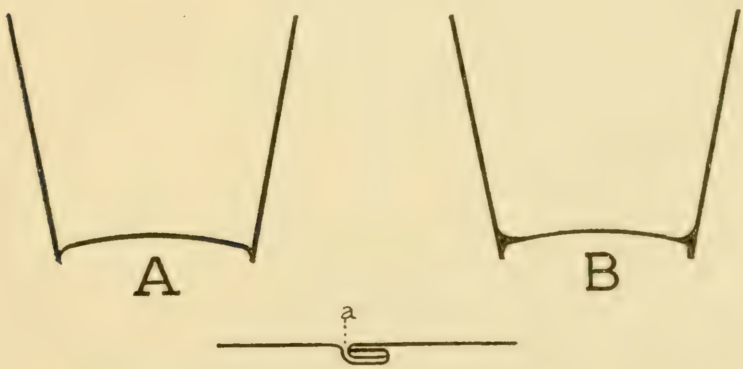
Third. Bacteria growing in milk may cause its decomposition, and consequently bad odors.

80. Bacteria.

Bacteria get into the milk during the process of, and subsequent to, the time of drawing from the udder. A few bacteria may work their way up into the teat, but they are practically all expelled with the first few squirts.

The cow may have been lying down in filth, and during the agitation of milking the dust and hairs will be dislodged and fall into the milk. Each particle of dust, and each hair may have numerous bacteria clinging to it. The milker's hands and clothes may also be a source of infection. After the milk is in the pail, dirt in the crevices may contaminate it with bacteria, and as it goes on its way through different vessels, it may receive increasing contributions of germs. Milk delivered in open vessels in the cities, gets contributions from the dust blown about the streets. Several hundred bacteria have been counted on a single hair.

IMPROPER PAILS.



A and a show crevices in seams into which the milk goes, forming a layer of food for bacteria. B shows how the crevices should be filled with solder.—Russell.

Milk from four dirty cows in a clean barn with clean milkers gave an average of 90,000 bacteria in each cubic centimeter of milk, while clean cows under the same conditions gave only 2000, or only one-forty-fifth as many.

In a case where there were twelve cows in a stable, a bacterial count showed the milk of eleven to contain few bacteria, but the milk of the twelfth one standing

next to a pile of dry feed contained 100,000 per cubic centimeter.

Dry feed handled just previous to, or during the time of milking, may furnish bacteria-laden dust.

81. Germicidal Properties of Milk.

Dr. W. H. Conn says that milk has a germicidal property. There is a preliminary period of the decline of the number of bacteria, this period varying from three to forty hours according to the temperature, and also possibly with the cows. At 70°, this period is six to nine hours. At 50°, it is forty hours.

82. Growth of Bacteria.

When the germicidal property of the milk is exhausted the germs increase in numbers, but the rate of increase is reduced by low temperature.

Rate of increase of single germ:

	2 Hours.	3 Hours.	4 Hours.	5 Hours.	6 Hours.
At 54°	4	6	8	26	435
At 97°	23	60	215	1830	3800

Bacteria found in milk may be classified as neutral, lactic, putrefactive and pathogenic.

In milk are found numerous species of bacteria that increase in numbers, but do not seem to change the character of the milk any.

The lactic bacteria are those that have the property of souring milk, of which about 200 species have been observed.

83. Acidity of Milk.

The caseine of milk has an acid reaction so that cow's milk freshly drawn from the udder will show .10 to .15% of what is usually classed as lactic acid, though it is not such. The bacteria act on the milk sugar, breaking it

up into lactic acid. When .3% acid has developed the milk begins to taste sour, and at .7 or .8 of a per cent., according to the temperature, it curdles. The bacteria go on forming more acid until about .9% is present, and it then inhibits their growth. The sugar of which there was 5% when the bacteria began to grow, has not all been used up. There is still about 4% left.

Milk that has more than .7% acid is not commonly received at factories for butter and cheese making, nor by milk dealers for consumption. Lactic acid bacteria do not grow much below 45° F. Other more dangerous forms may grow below that temperature.

84. Putrefactive Bacteria.

Under the head of putrefactive forms we may class those bacteria that produce gas, digest the proteine, produce bad odors, and a few other peculiar kinds.

Cheese makers are often bothered with pin holes developing in the curd and cheese. These holes are due to gas-forming bacteria, one form being Coli communis, which is found in barnyard filth. Another form, found in northern New York and Canada, causes rusty spots in cheese. Still another kind causes slimy milk and grows at low temperatures. This particular germ is surrounded with a gelatinous envelope, and when the bacteria become numerous enough they make the milk ropy or slimy.

An odor resembling soft soap in milk has been traced to bacteria. It may be said that the putrefactive kinds of bacteria are usually associated with and arise from filthy conditions.

85. Pathogenic Bacteria.

Many forms of disease are traced to definite species of bacteria.

Probably one hundred epidemics of typhoid fever and diptheria have been definitely traced to the milk supply.

Probably one hundred epidemics of typhoid fever have been carried by milk, the original source being a well or spring, the water of which was used to rinse the pails and cans in it, and the milk afterward being put into these vessels was inoculated.

Lactic bacteria are likely present in very small numbers in the milk soon after it is drawn from the udder, and if present will multiply very rapidly and crowd out other forms. Lactic acid bacteria are very desirable in butter making and certain forms of cheese making. Pure cultures of bacteria are now put upon the market on a large scale. Orin Douglas, and Kieth of Boston and Chr. Hansen's Laboratory at Little Falls, New York, each does a large business.

86. How to Combat Bacteria.

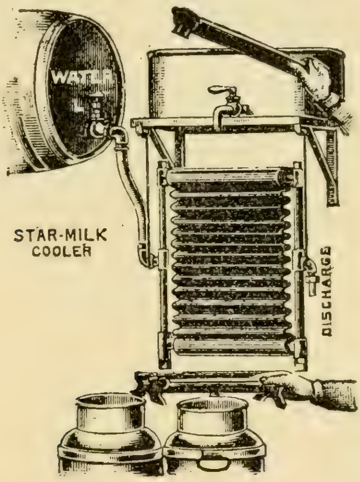
Bacteria may be killed with poisons such as formalin, boric and salicylic acids, etc., but in milk these are very dangerous to the health of people using the milk, are prohibited by law, and their use in milk is to be condemmed.

87. Keep Bacteria Out.

The best way to produce good milk is to prevent as far as possible the bacteria getting in. To this end the cows should be kept carded and clean, the stable should be well lighted and ventilated, hay should not be stored overhead if the floor is loose so that dirt may sift down. The stalls should be so constructed as to keep the cows out of filth.

88. Milkers.

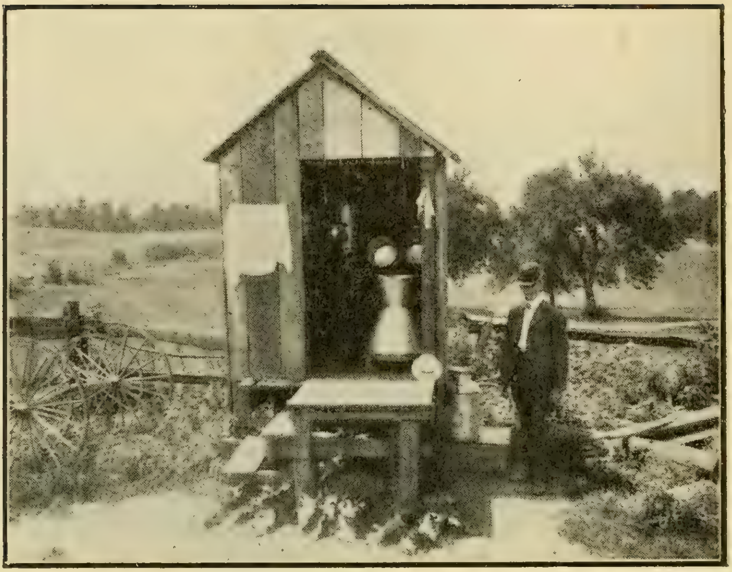
The milkers should have clean hands and suits, and just before milking, the flanks and udders should be wiped with a clean damp rag to lay the dust so that it will not fall into the milk pail. A pail with a top so constructed as to keep out the falling dirt, and at the same time can be easily cleaned, is desirable. Then the milk should be taken out of the stable as fast as



Star Milk Cooler.

milked, and strained and cooled. The most effective cooler is the Star, with corrugated surfaces over which the milk flows while cold water flows on the inside, and the milk can be cooled to within one degree of the water. The Champion cooler, which is a conical vessel over the surface of which the milk flows, is also effective.

Several sanitary dairies, one in Illinois, and others near New York City, which produce milk under such conditions as described above, packed milk in ice, sent it to New York where it was transferred to the refrigerator of an ocean liner, and then after seven days on the ocean,



Champion Milk Cooler as used by a patron of the National Milk Condensary, Kent, Ohio.

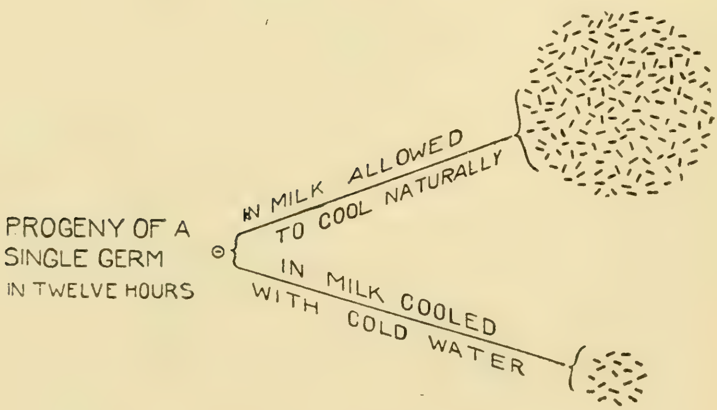


Diagram showing the effect of temperature on bacterial growth—Russell.

at Havre, France, was put into a refrigerator car, and arrived at the Paris Exposition in excellent condition, and was kept several days there until used, in fact milk eighteen to twenty days old was as good as French milk twenty-four to forty-eight hours old. All this was done by keeping dirt and bacteria out of the milk as completely as possible. A few bacteria probably got into the milk, but keeping it cold, extended the length of the germicidal period, and afterward kept the development of the few bacteria present in check.

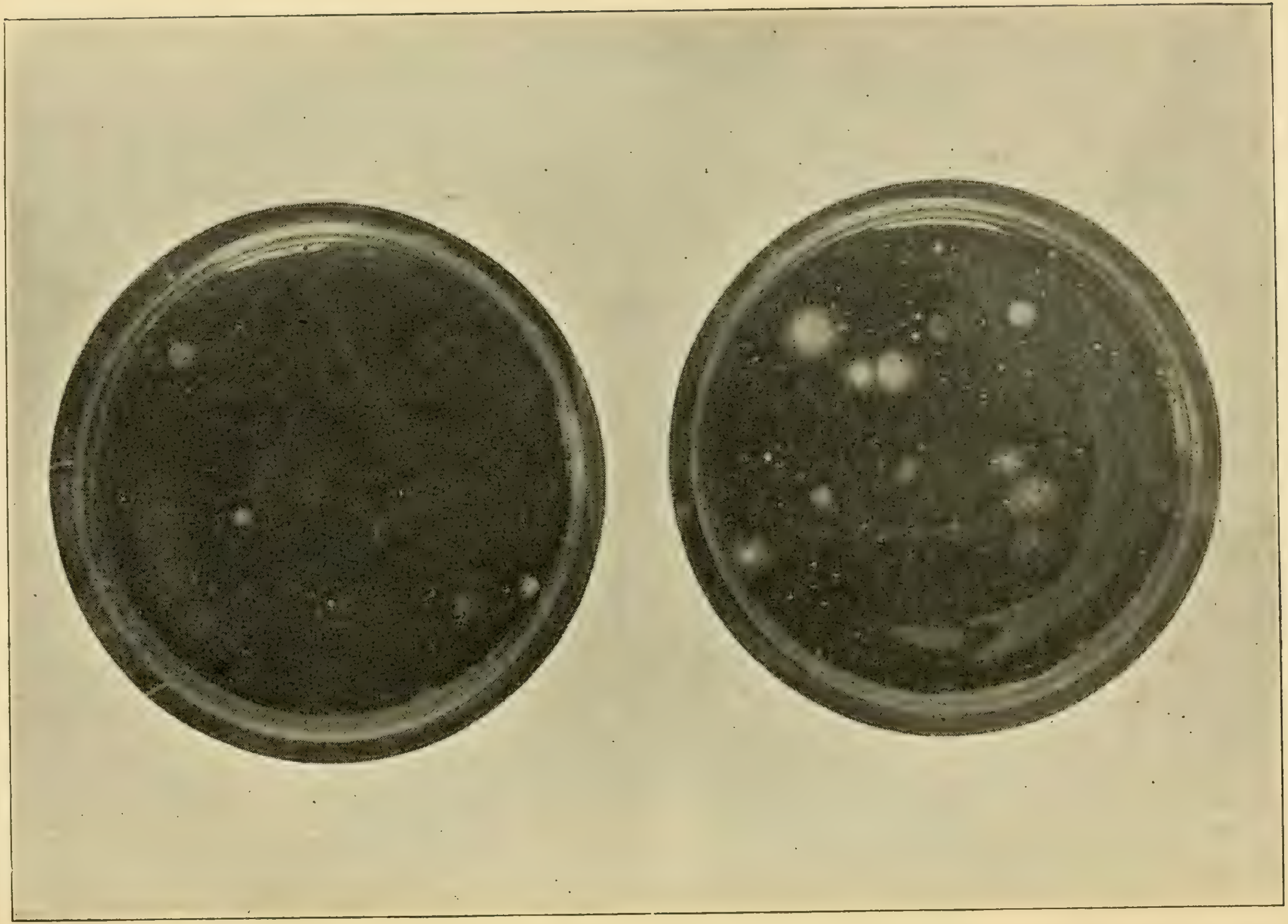
89. Sterilization.

But it is impossible to control a large milk supply as completely as just described, for farmers will be careless, and will not go to the extent necessary to keep the germs out as completely as desirable.

The only way to handle such milk is to kill the bacteria. This can be done by heat. To sterilize milk, that is kill all of the bacteria in the milk, it will be necessary to heat the milk above the boiling point under pressure. Some bacteria go into the spore stage; that is, go into a seed form, and these spores or seeds will stand high temperature, some kinds even a boiling temperature. But it is not practical to put milk under steam pressure, and if this were done the milk would have a disagreeable burnt taste, due to the changing of the albumen (which it will be remembered contains sulphur). It is evident that when people talk about sterilizing milk they do not understand what the sterilization of milk really involves. There is no sterilized milk on the market. They mean that milk is pasteurized.

90. Pasteurization.

By heating milk to lower temperatures than the boiling point for some time, all vegative or growing



This illustration is from a photograph taken by Dr. H. L. Russell, Wisconsin Experiment Station. Two glass dishes three inches in diameter were exposed under cows' udders for thirty seconds, the one shown on the left under an udder brushed and dampened before milking, the one to the right under ordinary conditions. Each place where a germ fell a colony grew as shown by the light spots.

bacteria may be killed, which may be 99% of those present.

91. Two Types of Pasteurizers.

There are two types of pasteurizers used, the continuous and the intermittent. The continuous pasteurizer heats a stream of milk which may be in a layer against a steam-heated surface in the machine, and after it passes out of the machine in a few seconds, may, or may not, be immediately cooled.

The intermittent machine has a charge of milk or cream put into it which is heated to a desired temperature, at which temperature it is held for a given length of time, and then quickly cooled. The intermittent machines will not handle as much milk per hour as the continuous kind.

Milk heated to 176° F. for ten seconds will have 99% of the bacterial content killed. The same milk heated to 160° F. will not be as effectively pasteurized. But five minutes at 160°, or ten minutes at 155°., fifteen minutes at 150° F., or thirty minutes at 140° F. will be as effective as five seconds at 176° F.

But milk dealers do not wish to take the time to pasteurize with an intermittent machine. They want to put a large amount of milk through in a hurry and consequently use the continuous machines. But at temperatures above 160° F. a burnt taste begins to appear, which is disagreeable to customers, and they therefore cut the pasteurizing temperature down to 160° F., which may kill out a good many bacteria, but is not really effective. The lactic acid bacteria do not form spores and are killed out before some of the putrefactive kinds, and often such pasteurized milk will develop gaseous, ill-smelling fermentations, without souring. The putrefac-

tive fermentations may cause bowel troubles, and by inefficient pasteurization, milk may really become injurious to health.

The lactic acid bacteria would sour the milk, so that it might be rejected, but it would not be harmful.

Dr. Russell reports a comparison of continuous and intermittent pasteurizers at 150° F., as follows:

	Bacteria Per c. c.
First Trial—	
Normal milk	34,603,000
Continuous machine	2,732,000
Intermittent machine	5,400
Second Trial—	
Normal milk	9,781,000
Continuous machine	661,000
Intermittent machine	6,000

H. A. Harding, at Geneva, New York, found with another style of continuous machine, that one day the bacteria were killed out down to 120 per cubic centimeter, and the next day 62,790 were left.

At 176° F. a series of trials showed uniformally low results, ranging from 20 to 297, and higher temperatures were but little more effective.

CHAPTER IX.

TESTING COWS.

92. The Cow's Milk.

A cow never made an ounce of butter. Men skim the milk, churn the cream, and get butter out of it, and butter has a commercial value. The conclusion is that a cow may be valued in terms of butter. How much butter can be made from the milk given by a cow, in a day, or a week, thirty days, or a year? The cows give the crude material, butter fat, and men make it into butter. The cow that has the capacity of turning food into a large amount of crude material is valuable for breeding purposes.

93. Some Jersey Records.

The Jersey cattle are noted for the rich milk that they give, and Jersey breeders have established a list of officially-tested cows, published in two volumes, entitled, "Butter Tests of Registered Jersey Cows."

On page 1, volume I is the record of Princess 2d (8046), the cow that holds the world's record for one week's test. The test was made February 22 to March 1, 1885, at the age of eight years. She is reported to have given 299 pounds eight ounces of milk, from which was made 46 pounds 12½ ounces of butter.

If the butter made contained but 80% of butter fat, and if no butter fat was lost in the skim milk and buttermilk, 37.42 pounds of fat would be required to make the amount of butter given, and that amount of fat in the

weight of milk given would require the milk to average for the week 12.5% fat.

Toltec's Fancy (27172), recorded on page 4 of the same volume is reported to have given 130 pounds 4 ounces of milk, from which 27 pounds 5½ ounces of butter was made. On the same basis of figuring, her milk must have averaged 16.7% of fat.

Harry's Pet (52838), recorded page 8, volume II, is reported to have given 157 pounds 10 ounces of milk, from which was made 22 pounds 11 ounces of butter. On the same basis her milk must have averaged 11.5% fat for one week.

In July, 1900, the Babcock milk test was introduced to the world. Since then thousands of cows have been tested, and many cows of great value in the Jersey and other breeds have been revealed. In the thirteen years of the history of the Babcock test, no cow has been reported as giving milk averaging 9% fat for a week, and it is a question whether there are cows that will give more than twenty-five pounds of fat in a week. It is a rare thing to find one giving over twenty pounds.

94. Columbian Exposition Test.

At the Columbian Exposition a series of tests for cheese and butter were conducted for different lengths of time. The Jersey, Guernsey and Shorthorn cattle were represented. Some excellent records were made in which the Jerseys took the lead, but it is a noticeable fact, that after scouring the country for the best cattle obtainable, there were none that averaged over six per cent. fat. Brown Bessy (74997), the champion cow, was calculated to have given fat equal to 3.48 pounds butter on her best day. This is calculated on a basis of 80% fat, which basis afterward led the Holstein-Friesian

Association astray. Her highest consecutive seven days work was calculated to be 20.163 pounds of butter.

One year previous to the exposition, the author tested this cow for the American Jersey Cattle Club. She then was 188 days in lactation, and averaged 34.36 pounds milk per day, testing 5.47% fat, equal to 1.88 pounds fat.

95. Holstein-Friesian Tests.

The Holstein-Friesian Association has for some years conducted an advanced registry of tested cows. The tests have been conducted under the supervision of the various agricultural experiment stations, a representative weighing and testing the milk.

96. Impossible Over-run.

Along with the statement of the test a statement has been published by the association of how much butter of 80% fat, the fat made would be equal to, and the next statement made has likely been that the cow made so much butter, without any reference to butter fat. This makes an overrun of 25%. The cow never made any butter, and no man can make as much marketable butter as stated, from that amount of fat, and the statement becomes a misrepresentation. At the 1903 annual meeting of the association, it was decided to allow an overrun of one-sixth. This is within the possibilities, but when they get down to a simple statement of milk and butter fat it represents just what the cow does.

97. Guernsey Tests.

The American Guernsey Cattle Club reports tests of one year's work. In the past the owner reported the daily weights of milk, and samples of two consecutive days' milk were sent each month to the experiment station to be tested. Different representatives of the club

appeared at different times during the year and weighed the milk and took samples of the milk to be tested, and comparisons were made with the weights recorded by the owner and with the samples of milk taken by him. A later plan requires an experiment station representative to personally supervise the milking once a month and do the testing.

The two-year-old cow Dolly Bloom (12770), advanced registry 40,—bred by Ezra Michener of Michener, Pennsylvania, now owed by F. Lathrop Ames, of "Longwater," North Easton, Massachusetts, has completed a year's record, as follows:

1902.	Milk, Pounds.	Per Cent. Fat.	Pounds Fat.
March, 26-30	149.00	4.25	6.33
April	795.50	4.25	33.81
May	869.63	4.56	39.66
June	909.81	4.40	40.03
July	846.69	5.23	44.28
August	795.25	5.17	41.11
September	703.19	5.60	39.38
October	688.50	5.30	36.49
November	691.44	5.55	38.37
December	694.50	5.60	38.89
January	641.63	5.80	37.21
February	543.69	5.73	30.61
March, 1-25	512.75	5.40	27.69
Totals	8841.58	5.13	453.86

She was dropped April 14, 1900, making her 23 months old when she dropped her calf.

98. Value of Testing Cows.

The purpose of the author in this chapter is not to discredit the testing business. That the reader may be able to estimate the value of properly conducted tests and to know what a proper test is, attention has been called to some of the unfavorable things. Our atten-

tion will now be turned to the manner of testing and to the observance of peculiarities in results.

99. How to Proceed.

The cow's milk should be weighed at each milking. A large spring balance made for this purpose is the best scale obtainable. The dial should be graduated to tenths of a pound, as the decimal system is much easier to compute than pounds and ounces. A sample can be tested from each milking, or a composite sample of a week, or a few days can be taken. A pipette made by drawing in the ends of a glass tube, ten or twelve inches long, in a gas flame can be easily made. A scale can be made by pasting a strip of paper on the side and dividing it into quarter inch spaces. Number the marks from the bottom to the top. With this pipette take a sample of milk of as many divisions as there are pounds of milk in the mess. In this way a proportionate sample can be obtained. The sample is delivered into a composite sample jar, which has some preservative in it, to keep the milk for the period desired.

A week will usually cover the usual fluctuations in daily fat yield, and so give a fair average.

To establish a year's record for a cow, the milk should be weighed at each milking, which operation is a small amount of labor. Fat tests should be made for at least two days each month, or for a longer period at least four times in the year. It is not a rare thing for a cow to vary two or three per cent. of fat from one milking to the next.

100. Tests of Single Milkings Unreliable.

If the record of a cow is based on a single test, it will make considerable difference whether the high or low

testing sample happens to be taken as the basis of calculation.

101. Professor Farrington's Experiments on Averages.

Professor Farrington has for several years conducted careful tests of cows in the herds of patrons of the University creamery. Composite samples of all of the milk given in a year by the cows were tested once a week.

Samples for single days (two milkings) were taken at different lengths of time apart, to determine, as compared with the record of samples of all the milk given by the cows, the accuracy of computing averages when testing and weighing the milk once in seven, ten, fifteen or thirty days. Averaging the results from seven of the most variable cows, the results were as follows:

Once in seven days, gave 98 per cent. of the total milk and 98 per cent. of the total butter fat.

Once in ten days, gave 98 per cent. of the total milk and 99.4 per cent. of the total butter fat.

Once in fifteen days, gave 97.6 per cent. of the total milk and 98.5 per cent. of the total butter fat.

Once in thirty days, gave 96.4 per cent. of the total milk and 97 per cent. of the total butter fat.

Richness of milk, or a large flow of milk for a short time, will not necessarily make a cow a large producer of butter fat.

102. Milk Flow and Richness Combined.

A combination of rich milk and a large persistent flow are the factors making a large record, as is shown in the case of Dolly Bloom.

The best cow is the one that makes the most butter fat in the year at the least cost. A cow must produce about 170 pounds of butter fat to pay the cost of keep-

ing. A cow should give at least 250 pounds of fat per year to be really valuable.

Below are given the records of some creamery cows as reported by Professor Farrington in Bulletin 75 of the Wisconsin Experiment Station:

Table showing milk and fat yields of Wisconsin cows:

Cow No.	Age.	Days Milked.	Pounds Milk.	Per Cent. Fat.	Pounds. Fat.	Factory Value of Milk.	Value Fat Per Pound
25	6	365	7,887	3.95	312	$58.25	18.6
1	7	303	6,182	4.8	296	53.25	18
9	7	273	3,792	3.9	147	28.72	19.5
10	9	209	4,061	3.9	160	32.13	20

In the above table to make the facts still plainer the factory value of the butter fat is stated. Some of the cows came fresh in the fall, and winter butter fat brought higher prices, which explains the varying values of butter fat, which modify the results somewhat.

Comparing cows Nos. 1 and 9 it is evident that the flow of milk should be large as well as persistent.

103. Value of Pedigree.

As an illustration of the value of registered full blood cows over common stock, a record of official tests of Guernsey cows in Wisconsin, 1898-99, published in the Wisconsin Experiment Station, Report XVII, is given below:

Name.	Registry No.	Age.	Pounds Milk. in 1 Year.	Pounds. Fat.	Per Cent. Fat.
Lilly Ella	7240	5	12282.68	782.16	6.42
Lilyita	7241	5	12812.73	710.53	5.69
Countess Bishop..	7869	4	7387.3	452.23	6.42
Madam Trickesy..	6519	6	7024.6	405.19	5.85
Lady Bishop	6518	7	6608.9	381.1	5.40
Pristoun	6570	7	6868.3	355.68	5.19
Nounon	6569	9	6338.0	351.7	5.51

A year's record established in this way may have points for criticism, but is more valuable in estimating the value of an animal, than a test for a short period under pressure, as in the seven-day test.

104. Unusual Test of Duchess of Ormsby.

An unusual test of the Holstein-Friesian cow Duchess of Ormsby (16004) was made under the author's direction. She was tested in January, 1899, giving 356.9 pounds of milk, averaging 5.44 per cent. fat, or 19.41 pounds of fat. Her best milking showed 18 pounds of milk, testing 6.3% fat, and her poorest milking 19.7 pounds, testing 4.65% fat. This was phenomenal for a Holstein, and Professor Woll went to the farm the following week, and secured samples which tested over 5% fat.

Her milk flow increased, and on February 24 another seven-day test was started, in which she gave 387.1 pounds milk, but the average fat dropped to 4.29 per cent., a total of 16.61 pounds of fat. The milk flow continued to keep up and on May 16 a third seven-day test was begun, which resulted in 381.5 pounds of milk, averaging 3.67% fat, or 14.02 pounds.

We have no satisfactory explanation to offer for this peculiar and unusual variation in fat test.

Attention has already been called (pp. 38-41) to some of the usual variations in fat test.

105. Difference Between Mean and Average.

Sometimes patrons at creameries take samples from the milk of each of their cows to have them tested. The percentages will be added and the sum divided by the number of cows. The result quite often shows a higher percentage than the average weekly test and there is

trouble ahead for the butter maker. The result so obtained is not an average, but an arithmetical mean.

In securing an average, the weights of milk given by the cows must be taken into consideration, as well as the fat tests.

The following example will explain this. A man has two cows which give milk and test as follows:

	Pounds Milk.	Per Cent. Fat.	Pounds Fat.
No. 1	50	3.0	1.50
No. 2	20	5.0	1.00
Total	70		2.50

The arithmetical mean is obtained by adding the percentages and dividing by 2, which gives 4 as the mean.

The average is obtained by dividing 2.5 by 70 and multiplying by 100, which gives 3.57% as the average.

CHAPTER X.

Market Milk

106. Value of Milk and Cream.

"Milk and milk products have had a most important effect upon the dietary of civilized people. Among high class food products, few are more healthful than milk when it is pure, and few food products contain greater possible dangers than when it is not pure.

Many people restrict themselves in the use of milk under the impression that they are practicing economy. As a matter of fact one quart of milk containing five per cent. of butter fat has a food value equal to five-sixths of a pound of sirloin steak, to say nothing of the greater ease of serving or its greater healthfulness. A pint of cream, containing twenty per cent. of butter fat has a food value equal to five quarts of strawberries. This does not mean that one should be used to the exclusion of the other, but milk and cream are articles of diet that deserve a much greater use both from the standpoint of economy and healthfulness than are at present accorded them."—Dr. Thomas F. Hunt.

107. Ancient Methods of Milk Delivery.

With the advance of modern civilization the milk supply for purposes of consumption of our country is keeping step. In unprogressive cities of the East the milkman proves the purity of his milk by driving the cow up to the door to be milked, but the unsuspecting public does not know that the first customer who gets

the fore milk gets skim milk, while the one who gets the strippings gets cream.

108. Cans vs. Bottles.

The milkman in our cities who delivers his milk from cans and measures the milk for each customer drives over the dusty streets filling his measures with dirt as he goes. The glass bottle securely capped prevents this. While more expensive, it is claimed that the extra milk that has to be given in the other method for good measure, together with the milk that is slopped, will pay the cost of the bottles.

Glass bottles may, however, be more unsanitary than the other method if the bottles are not properly washed by the milk dealer. Bottles come from homes of questionable cleanliness or from homes harboring disease, which may be carried to other customers through the milk bottles. It is therefore necessary to thoroughly wash and sterilize the bottles. The washing is usually done with a brush revolving on a shaft, and then sterilized by placing the bottles in a chamber which is then filled with live steam. All utensils which are used in contact with the milk should be likewise sterilized.

A new bottle washer used in large establishments takes the bottles placed in two rows in racks, a dozen bottles in a rack. They are first subjected to jets of hot salsoda solution, next to jets of hot rinsing water, and third to jets of hot steam, coming out of the other end of the machine washed and sterilized.

109. Milk Tickets.

It is evident that milk tickets which are used many times may become dirty and so become conveyers of disease. Coupon tickets which are sold in strips, from

which pint or quart squares can be detached and destroyed after once using, are coming into favor.

110. Market Terms.

Milk is sold under a number of different terms, such as pasteurized, aerated, certified, standardized, and modified. Pasteurized milk has already been considered.

111. Aerated Milk.

Aerated milk is milk that has been subjected in fine streams to the air. Among cheese and butter makers aeration is considered very essential, but experiments at a number of experiment stations have led to the uniform conclusion that the only value of aeration is in cooling the milk, which cooling very naturally retards bacterial growth.

112. Certified Milk.

Certified milk is so called, because the producer has an arrangement with physicians to take samples for chemical and bacteriological analysis, and to inspect the cows, premises, etc., after which the physicians make a certified statement that all such provisions have been complied with, and that the milk is pure in every respect.

113. Standardized Milk.

Standardized milk is milk standardized to a certain per cent. of fat. Often milk producers guarantee to sell milk or cream of a certain standard per cent. of fat for a certain price.

It is necessary in such cases to take out some skim milk, making a higher percentage of fat. It is clearly illegal to abstract any fat from whole milk and then sell it for anything else but skim milk.

114. Standardizing from Cream and Skim Milk.

As an example of the method pursued, suppose we are standardizing milk to 5% butter fat. We have 322 pounds of milk testing 4.4% fat, or it contains 13.846 pounds of fat, which divided by 5, the per cent. of fat required, gives 2.769 and this multiplied by 100 gives 276.9 pounds of milk that it will make. We run the milk through the separator and obtain perhaps 45 pounds of cream. The amount of cream we get and its richness each day will vary with the temperature of the milk, the rate at which the milk goes through, or the speed of the machine. It is impossible on account of these factors to take a cream of a certain per cent. of fat each day. It is therefore necessary to take a richer cream than is desired and thin down with skim milk. In such a case as the one under consideration, it will not be necessary to test the cream for fat. If the separator skims close, practically all of the fat of the milk will be in the cream. We now add enough skim milk, 231.9 pounds, to the 45 pounds of cream to make the desired 5% milk, and 45.1 pounds of skim milk is left over.

115. Standardizing from Two Qualities of Milk.

Another proposition in standardizing a certain amount of milk to a certain standard when milks of different per cents. of fat are at hand is as follows:

Example: Make 500 pounds of 4% milk from milks containing 5% and 3.2% fat. How much of each should be used to make the 500 pounds desired?

500 pounds of 4% milk contains 20 pounds of fat.

500 pounds of 5% milk contains 25 pounds of fat.

500 pounds of 3.2% milk contains 16 pounds of fat.

Every pound of 5% milk contains .05 pounds of fat.

Every pound of 3.2% milk contains .032 pounds of fat.

Every pound of 5% milk replaced by 1 pound of 3.2% milk reduces the fat by the difference .05 — .032 = .018 pounds.

25 pounds — 20 pounds = 5 pounds of fat to be taken out by replacing 5% milk with 3.2% milk.

.018 pounds is contained in 5 pounds 277 times.

Therefore, 277 pounds of 3.2% milk is to be used in place of that much 5% milk, and 233 pounds of 5% milk will be required to make the amount up to 500 pounds.

233 lbs.	5 %	milk contains	11.15	lbs. fat
277 lbs.	3.2 %	milk contains	8.85	lbs. fat
500 lbs.	4 %	milk contains	20.00	lbs. fat

Q. E. D.

These methods are applicable to the standardization of cream as well as of milk, excepting that it may possibly be necessary to test the cream to be used.

116. Value of Milk and Cream on Fat Basis.

A common problem that comes up in this connection is that of the price of milk or cream by the gallon when the milk is bought on the fat test. For example:

When milk of 4% butter fat costs $1.44 per 100 pounds, what will be the cost per gallon of, first, 5% milk; second, 20% cream.

At $1.44 per 100 pounds, each pound of fat will cost 4 into $1.44, or 38 cents. A gallon of milk weighs 8.6 pounds and contains 5% of that weight, or 4.3 pounds of fat, which at 38 cents per pound would be 16.34 cents. More butter fat in the cream lowers the specific gravity so that a gallon of 20.% cream will weigh about 8.3 pounds and contain 1.66 pounds of fat, which at 38 cents per pound would be worth 63.08 cents.

117. Modified Milk.

Cow's milk is used largely as the food for babies, the great majority of them being obliged to resort to it in whole or in part. So far in this book, we have been considering cow's milk, which varies from the milk of other species both in the amounts of the different constituents present, and also in the character of the constituents. The new-born calf has more hair, stronger bone framework and stronger muscles than a new-born baby. Its stomach and digestive tract is also very different, and it is no surprise to find that the food of each as prepared by nature is different.

The following table shows the percentage composition of the milk* of different species of mammals. It should be remembered that cow's milk has been studied much more than the milk of other animals and more data are available for conclusions and also that the thoroughness of emptying the milk glands may have affected the analyses here reported.

Animal.	Per Cent. Water.	Per Cent. Fat.	Per Cent. Proteine.	Per Cent. Sugar.	Per Cent. Ash.
Cow	87.17	3.69	3.55	4.88	.71
Sheep	83.50	6.14	5.74	3.96	.66
Goat	86.91	4.09	3.69	4.45	.86
Mare	90.06	1.09	1.89	6.65	.31
Ass	90.00	1.30	2.10	6.30	.30
Human ...	88.20	3.30	1.50	6.80	.20

—According to Koenig.

118. Objectional Features of Cow's Milk for Babies.

It will be observed that mother's milk contains about the same fat, more sugar, half the proteine, and one-third the ash of cow's milk. But this difference is not all. The proteine is quite different. It will be remembered that the caseine of cow's milk has an acid reaction. Mother's milk is alkaline. Cow's milk curdles by the rennet in stomach in a hard clot, and the calf's stomach

is constructed to handle such a lump. The baby's stomach is small, with a small opening into the intestine where the greater part of the digestion takes place. Such a hard clot cannot get out of the stomach and consequently causes distress for the baby.

The proteine of mother's milk does not curdle in a large lump, but in fine flakes that readily pass through the small opening into the intestine where they can be digested.

119. Methods of Modification.

If cow's milk be mixed with an equal quantity of water, the solids will be reduced one-half. This leaves the amount of proteine right, but has reduced the fat which was just right before diluting, as well as the sugar which was insufficient. Either cane or milk sugar can be added to bring the percentage up to the desired standard, and fat can be added in the form of cream. If the milk be allowed to stand until the cream rises and the top half be taken for dilution with water, it serves the same purpose as adding cream, and all that is necessary after dilution will be the addition of sugar.

120. Effect of Water in Cow's Milk.

But the addition of water to the cow's milk accomplishes more than just the dilution of the proteine. It retards the formation of a clot, and when the clot does form, it is less firm and often flocculent like the flakes of mother's milk. Sometimes a little limewater is added to the milk. This being alkaline also retards the rennet action. Milk that is sour will curdle much quicker and form a firmer clot than sweet milk. Milk changed as just described is called modified milk. It is now carefully prepared on a commercial basis.

121. Walker-Gordon Laboratories.

It is said that A. V. Meigs, of Philadelphia, made the first attempt at such milk, and that later Rotch, of Boston, took it up. George E. Gordon, of Boston, began the work on a commercial basis in 1893, and the Walker-Gordon laboratories of our large cities are the result. So important and well financed is this work that the Assistant Chief of the Dairy Division of the United States Department of Agriculture, was willing to leave his position with the government, to take charge of one division.

They have laboratories at Boston, New York, Philadelphia, Chicago, Baltimore, Providence, St. Louis, Buffalo, Cleveland, Pittsburg, Cincinnati, Montreal, Ottawa, Toronto, and London, England. Babies moving from place to place may have their prescriptions transferred from one laboratory to another.

While they give suggestions as to the composition of milk and publish the following table of compositions for babies of different ages, they do not prescribe. The family physician writes out the prescription denoting composition, amount for the day, and the number of feeds, and the prescription is followed until a change is ordered. The milk is put up according to prescription and filled into six or ten-ounce nursing bottles, and a cotton plug inserted in the mouth. The bottles are then placed in a basket and the whole set into a steam chamber into which live steam is introduced, and the temperature raised to 150° F. for twenty minutes. The bottles are then taken out and set in ice water until ready for delivery. The basket is delivered to the house and the bottles of the previous day returned to the laboratory. As wanted, a bottle is taken out of the basket, the cotton

plug is removed and a rubber nipple drawn over the end of the bottle.

ABSTRACT FROM MEDICAL RECORDS OF THE WALKER-GORDON LABORATORY.

TABLE SHOWING THE AVERAGE PERCENTAGES EMPLOYED, AND THE AMOUNT OF MODIFIED MILK FED TO A LARGE NUMBER OF INFANTS.

Weeks of Life.	Amouut Fed in Ounces.	Percentages. Fat.	Sugar.	Proteids.
First	1¼	2.00	4.50	0.75
Second	1¾	2.50	5.50	1.00
Third	2	3.00	6.00	1.00
Fourth	2¼	3.00	6.00	1.00
Fifth	2¾	3.25	6.50	1.00
Sixth	3	3.25	6.50	1.25
Seventh	3	3.50	6.50	1.25
Eighth	3¼	3.50	6.50	1.25
Ninth	3½	3.50	6.50	1.25
Tenth	3½	3.50	6.50	1.25
Eleventh	3½	3.50	6.50	1.25
Twelfth	3¾	3.50	6.50	1.25
Thirteenth	3¾	3.50	6.50	1.25
Fourteenth	4	3.50	6.50	1.25
Fifteenth	4¼	3.75	6.50	1.25
Sixteenth	4¼	3.75	6.50	1.25
Seventeenth	4½	3.75	6.50	1.50
Eighteenth	4½	3.75	6.50	1.50
Nineteenth	4¾	3.75	6.50	1.50
Twentieth	4¾	3.75	6.50	1.50
Twenty-first	4¾	3.75	6.50	1.50
Twenty-second	5	3.75	6.50	1.50
Twenty-third	5	3.75	6.50	1.50
Twenty-fourth	5¼	3.75	6.50	1.75
Twenty-fifth	5¼	3.75	6.50	1.75
Twenty-sixth	5½	3.75	6.50	1.75
Twenty-seventh	5½	4.00	6.50	1.75
Twenty-eighth	5½	4.00	7.00	1.75
Twenty-ninth	5¾	4.00	7.00	1.75
Thirtieth	5¾	4.00	7.00	1.75
Thirty-first	6	4.00	7.00	1.75
Thirty-second	6	4.00	7.00	1.75
Thirty-third	6¼	4.00	6.50	1.75
Thirty-fourth	6¼	4.00	6.50	2.00
Thirty-fifth	6¼	4.00	6.50	2.00
Thirty-sixth	6¼	4.00	6.50	2.00
Thirty-seventh	6½	4.00	6.50	2.00
Thirty-eighth	6½	4.00	6.50	2.00

Weeks of Life.	Amount Fed in Ounces.	Percentages.		
		Fat.	Sugar.	Proteids.
Thirty-ninth	6½	4.00	6.50	2.00
Fortieth	6¾	4.00	6.50	2.00
Forty-first	6¾	4.00	6.50	2.00
Forty-second	7	4.00	6.50	2.00
Forty-third	7	4.00	6.50	2.25
Forty-fourth	7	4.00	6.00	2.50
Forty-fifth	7	4.00	6.00	2.50
Forty-sixth	7¼	4.00	6.00	2.50
Forty-seventh........	7¼	4.00	6.00	2.50
Forty-eighth	7¼	4.00	6.00	2.50
Forty-ninth	7¼	4.00	6.00	2.75
Fiftieth	7¼	4.00	6.00	2.75
Fifty-first	7¼	4.00	6.00	2.75
Fifty-second	7¼	4.00	5.50	3.00

PREMATURE INFANTS.

Amount Fed.	Fat.	Sugar.	Proteids.
	1.00	3.00	0.25
2-6 Drachms	1.00	4.00	0.50
	1.50	4.50	0.75

The percentages are given in the round numbers next nearest the actual percentages employed, and are approximate.

122. Rubber Nipples.

The rubber nipple must be carefully washed in warm water and kept in an antiseptic solution of boric acid, for rubber is porous and will soon absorb milk and get foul.

123. Filling Prescriptions.

The modified milk is prepared from the contents of four vessels. No. 1 contains cream of standard butter fat, say 25%. No. 2 contains separator skim milk. No. 3 contains a 20% sugar solution. No. 4 contains distilled water.

First, enough cream is taken to supply the fat, but with the cream goes some proteine and sugar.

Next enough skim milk is added to furnish the difference in proteine between that added in the cream and the required amount. Sugar has been furnished with both cream and skim milk. Enough is now supplied to make up the deficiency, but the mixture is still short of the required volume. Water is added to complete the modification.

Such a prescription would be written as follows:

℞	Fat	3%	
	Sugar	6%	
	Proteine	1%	8-4 oz.

The composition of the milk is given, and it must be 32 ounces in volume, divided into eight four-ounce feeds; 32 ounces of the above prescription calls for: Fat, .96 ounces; proteine, .32 ounces; sugar, 1.82 ounces. To supply .96 ounces of fat, 3.8 ounces of 25% cream will be necessary.

BLANK FOR FILLING PRESCRIPTIONS OF MODIFIED MILK.

		Fat.	Proteine.	Sugar.
Required oz	32	.96	.32	1.82
Cream	3.8	.95	.141	.133
Skim milk	5.1	.01	.171	.245
Sugar solution	7.2	.00	.000	1.44
Total	16.1	.96	.312	1.818
Water to be added...	15.9			

On a blank for the purpose can be put down the fat thus added, together with proteine and sugar in the cream: .141 ounces proteine and .133 ounces sugar being thus added; .18 ounces of proteine is still lacking which is supplied by adding 5.1 ounces of skim milk, at the same time adding .245 ounces of sugar, making .378 ounces of sugar supplied in the cream and skim milk; 7.2 ounces of the sugar solution supplies the 1.44 ounces

still lacking and the solids are all accounted for. But only 16.1 ounces of liquid is the result of the combinations, but an addition of 15.9 ounces of the water expands the bulk to the required 32 ounces.

124. Effect of Food on Baby's Health.

A baby may grow and increase in weight, be plump and appear healthy on a diet of too much carbohydrate (sugar and fat). Proteine is necessary to supply muscle that will resist disease. It is therefore important that the proteine be not cut down too low in the modification.

Premature, undeveloped infants require weaker food, and whey which contains .75% of albumen, with a little cream added suits the purpose. Such a diet also works well with invalids with weak stomachs.

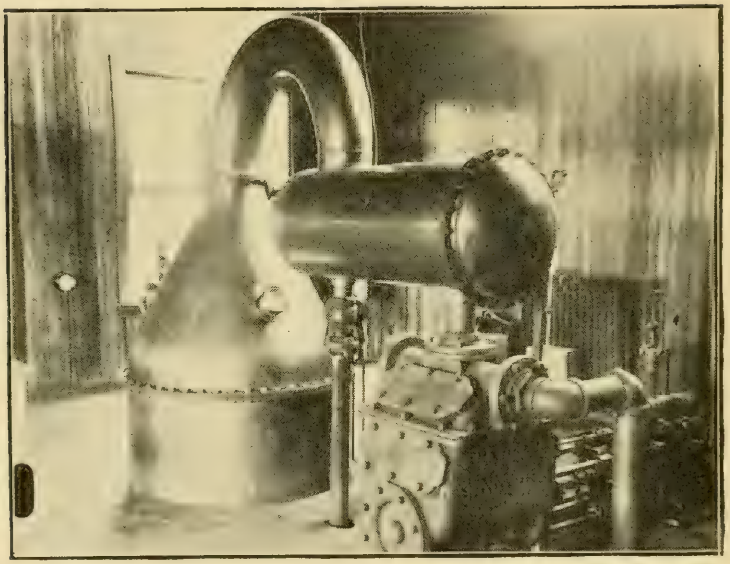
125. Market Cream.

Variations in the quality of cream have already been explained. Gravity cream usually varies between 18% and 25% fat.

The usual standard for market cream is 20%. What is known as double cream is usually about 30% fat. The District of Columbia, Minnesota and Oregon have a legal standard of 20%, Washington 18%, and in Illinois 15% for coffee and 22% for whipping cream. In Iowa, Nebraska and North Dakota the standard is 15%. The other states have legal standards for other dairy products, but not for cream. In Ohio a woman arrested for selling adulterated milk, set up the plea that she was not selling milk but cream, and was acquitted.

126. Condensed Milk.

Condensed milk is made by evaporating milk by steam in a copper vacuum pan to one-third or less of its original volume. Two kinds are made—sweetened and unsweetened, to the former of which is added before



Vacuum Pan in the National Condensed Milk Company's Factory at Kent, Ohio. The bottom extends through the floor into the room below, where the condensed milk is drawn off.

evaporation cane sugar equal in quantity to the solids of the milk.

A good share of the condensed milk on the market has been skimmed before evaporation. This can be shown in the case of unsweetened milk where the fat is less than one-fourth of the total solids. In New York, Ohio, and Oregon this standard is established by law.

Much of the evaporated or condensed milk on the market has a peculiar flavor due to heating to sterilize it.

Some condensed milk is kept cold in bulk and sold in that condition as filler for ice cream. It is also sold to bakeries for use in the manufacture of confectionery.

Evaporated cream is a fine quality of condensed milk.

127. Condensed Milk for Babies.

Condensed milk that has been skimmed, is often misrepresented as being a perfect food for babies, the misrepresentation being evident after the discussion of modified milk.

CHAPTER XI.

Dairy Refrigeration.

128. Field of Dairy Refrigeration.

Under the head of dairy refrigeration will be given a brief discussion of the physics of refrigeration, and of frozen products.

Refrigeration in the dairy is very important.

129. British Thermal Unit.

When a pound of water is raised from 35° F. to 36° F. a certain amount of energy is exerted and this is termed a (B. T. U.) British Thermal Unit.

130. Latent Heat.

When a pound of ice at 32° F. is changed into water at 32° F. 142 B. T. U. disappear in the change. On the other hand when a pound of water at 32° F. changes into ice at 32° F., 142 B. T. U. are given off to surrounding objects.

A pound of water rising from 50° F. to 60° F. will absorb in the operation but ten B. T. U.

131. Ineffectiveness of Running Water.

For this reason a refrigerator cooled by running water is not nearly as effective as melting ice. Water sprinkled, evaporates into vapor and takes up a great many B. T. U. in the operation and may thus lower the temperature of the air appreciably. The psychrometer is an illustration of this. Take two thermometers and place a wick on the bulb of one, wetting the wick. The evaporation of the water from the wick will lower the mer-

cury in that thermometer below that of the other in proportion to the dryness of the air. If it is desired to cool 100 pounds of milk from 60° to 40°, the work of 2000 B. T. U. will be required, equal to 14.1 pounds for just the cooling, but as there will likely be some radiation of heat from the milk vat, more ice than that must be added to accomplish the desired result. If it is desired to cool a quantity of milk with water the number of effective B. T. U. in each pound of water must be calculated and then the water supply estimated. A creamery man can calculate the ice required for his season's work by determining the refrigeration required in B. T. U. for a day, and then multiplying it by the number of days refrigeration required. In cooling warm or hot milk it is not economical to cool from the first with ice, but the effectiveness of the water supply should first be exhausted.

132. Artificial Refrigeration.

Artificial refrigeration is accomplished by the use in iron coils, of a medium that under high pressure is a liquid, but at ordinary temperatures and pressures is a gas. Carbon dioxide and anhydrous ammonia are commonly used, the latter more than the former. Liquid ammonia at 150 pounds pressure per square inch, and at a temperature of perhaps 60°, is allowed to spray through a small opening into a coil under lower pressure, where it immediately changes into gas. The latent heat as in the case of ice changing into water disappears in the change, but takes this heat from surrounding objects, and the coil if in the air begins to frost over and cool the air, or if in a liquid as brine will cool it. The gaseous ammonia is pumped by means of a gas pump, or compressor as it is called, into a coil where it is put under perhaps 180 pounds pressure, instead of 20 pounds, and

the temperature rises because of the compression in a gaseous state. Cold water flows over the coil, reducing the temperature, and when just the right temperature for that pressure is reached, the gas turns into a liquid again, and can be used once more in the same manner. To make an artificial refrigerating plant economical, plenty of cold water for the cooling of the gas is necessary, for the lower the temperature of the gas in the condensing coil can be carried by the water, the lower the pressure necessary for the condensation, and the lower the pumping pressure, the less power it will take, and less power means less fuel. Ammonia pressures are usually 130 to 200 pounds per square inch and carbonic anhydride 600 to 1000 pounds.

133. Insulation Important.

An important thing in a good refrigerator is good insulation. If the walls are such that the heat gets in, the effectiveness of the refrigeration is impaired. Plenty of dead air spaces, or granite rock wool, or granulated cork, are effective. Floors should be of wood and well insulated. Cement floors are good conductors of heat.

In case of artificial refrigeration, brine pipes should be thoroughly insulated.

134. Freezing Mixtures.

It is sometimes desirable to get lower temperatures than can be secured from melting the ice above. Such can be obtained by the use of freezing mixtures. Common salt has a great affinity for water, and will tear ice to pieces to get it; that is, will melt ice. Salt thrown into a frozen drain will melt it. When salt, with a little water to start it into solution, is thrown onto ice it changes it into water, and the required 142 B. T. U. involved in the change must come from surrounding objects.

Where plenty of natural ice is to be had, a cold storage with very low temperatures can be obtained by means of mixing salt with the ice in cylinders suspended from the ceiling.

Freezing mixtures can be used in the kitchen and in making ice cream. The brine from an ice cream freezer will sometimes stand at 0° F.

Freezing mixtures can be used in the kitchen with a baking powder can in a small pail of the mixture.

The more salt that is used the faster the mixture will act. An average freezing mixture is made by using one part of coarse salt to ten or twelve parts of ice by weight. In the kitchen, if ice is placed in a strong bag it can be easily, quickly, and thoroughly crushed with a mallet.

135. Ice Cream.

In making ice cream, the water in the serum freezes. Creams containing much fat freeze quickly and have more body, but do not chill the mouth as much as those of lower fat content. Cream of 25% fat gives a very good body, but more fat is undesirable as it soon satisfies the appetite. Creams of less fat content, 15%, are more apt to be granular on account of ice crystals, are colder because of more ice in the serum melting, and melt down into liquid quicker. One can eat more of such cream.

136. Ice Cream Fillers.

Fillers, that are cheaper than butter fat, are often used to give the cream body. Rice flour, or corn starch, are sometimes used, but can be detected by an alcoholic solution of iodine, which will turn the starch blue.

Gelatin is also often used. Such can be detected by diluting with water and precipitating the caseine and fat

with acetic acid. The clear filtered solution will give a copious white precipitate with tannin.

Condensed milk is used by some manufacturers to give the cream body. As this contains nothing but milk constituents its use seems perfectly legitimate. Milk powders recently put upon the market may also be used.

137. Frozen Junket.

Body can be obtained in milk or cream of low fat content, by curdling the same with rennet just before freezing. The cook can get liquid rennet from a drug store, the farmer can get rennet from the cheese factory, or regular junket tablets can be secured from Chr. Hansen's Laboratory, Little Falls, N. Y., with instruction for use.

138. Mixing Cream.

Ice cream is sweetened with sugar. Use 2½ oz. of sugar per 1 lb. of cream for other than fruit flavors, or 2 oz. where fruit flavors are used as fruit syrups contain sugar.

Flavoring extracts contain alcohol and ethers, and care should be taken not to use too much, as they may impart a disagreeable taste. They vary in strength but are used to suit the taste. If kept long they disappear from the cream.

Special flavoring extracts, sold only in wholesale quantities, to take the place of vanilla are on the market, as are also "German Fruit Oils" used to tone up natural fruit flavors.

139. Expansion.

In freezing cream the milk serum expands, the albumen is whipped, and the air bubbles are incorporated with the cream, so that 60% to 80% more ice cream can be taken out of the freezer than goes into it.

It is most light and feathery just before the cream sets, that is, when not quite frozen. If carried too far in the freezer, the expansion may largely disappear. If taken out of the freezer and frozen in a packing package, it will retain the expansion as long as solidly frozen, but if it partially melts, the air will go out and the expansion will disappear.

In case layer cream is desired, the different flavors should be packed evenly and the moulds filled to prevent the entrance of brine.

140. Freezing in Open Kettles.

In large plants where brine is available from artificial refrigeration, brine is allowed to run through the freezing tub in which a copper kettle revolves on an axis. The operator with a wooden paddle throws the cream up against the sides and in this way incorporates more air, making fine feathery cream.

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Three Pamphlets on Cheese Making, Butter Making and Pasteurization—By J. H. Mourad.

The Creamery Patron's Handbook—Published by the National Dairy Union, Charles Y. Knight, Secretary, 154 Lake St., Chicago.